



modulation

% of antenna current increase is 32.5%  
under sinusoidal modulation

ratio of peak current under modulation  
is (2) two times the unmodulated current  
ratio of power is 4 times

~~J B Snyder~~

~~██████████~~

Personal Property

Sander Brodman

3-49-B

556 O.I.F.C.R.D.

Personal Property

Peter Jastow

68th Ord. H.A.A. Maint. Det.

Aberdeen Proving Ground, Md.

Peter Jastow    R.C.A    Sept 45    3-1

225 Ashby Rd    Upper Darby, Pa.



# RADIO OPERATING QUESTIONS AND ANSWERS

*The quality of the materials used in  
the manufacture of this book is gov-  
erned by continued postwar shortages.*

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*Books by*  
ARTHUR R. NILSON  
AND  
J. L. HORNUNG

PRACTICAL  
RADIO COMMUNICATION

RADIO OPERATING QUESTIONS  
AND ANSWERS

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*by*  
ARTHUR R. NILSON  
RADIO CODE MANUAL

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*Real elements* 7

# RADIO OPERATING QUESTIONS AND ANSWERS

by Arthur R. Nilson

*Late Chief Instructor, Nilson Radio School, New York, N. Y.*

and J. L. Hornung

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EIGHTH EDITION

THIRD IMPRESSION

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RADIO OPERATING  
QUESTIONS AND ANSWERS

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## PREFACE TO THE EIGHTH EDITION

THIS EDITION marks the twenty-fifth year of the use of "Radio Operating Questions and Answers" as a standard technical radio review book and serves as a fitting memoir to its coauthor and originator, the late Mr. Arthur R. Nilson.

Since its first appearance in December, 1921, "Radio Operating Questions and Answers" has expanded from its original pamphlet form to the now new and popular pocket-size book. During these years the text has been constantly revised to maintain an up-to-date coverage of Federal Communications Commission license requirements. Many more questions covering a much wider range in both the engineering and operating field are now provided to prepare applicants for the type of examination adopted by the Government in 1939. The essay form of technical examinations employed by the FCC prior to that time is now almost entirely replaced by the popular multiple-choice form of examination.

The new edition of "Radio Operating Questions and Answers" has been prepared to give all new applicants for the government-license examinations a complete review of actual types of technical questions as given in the various classes of licenses for the radio operating and broadcasting field. Each question has been answered in essay form to facilitate rapid learning and to give a clear and concise interpretation of the actual examination questions. It is believed that with a clear technical understanding of each question the ease of differentiation as to the correct key answer in a multiple-choice type of examination is greatly improved.

Many of the answers have been revised to compensate for slight changes effected in the examinations during the past four years. Some new questions have also been added.

A new feature introduced in this edition is the adoption of the American Standards Association approved symbols for

## PREFACE TO THE EIGHTH EDITION

radio, telephone, telegraph, and electronics circuits. All circuit illustrations have been completely revised to conform with the new standards. It is believed that with the rapid transition already under way in industry both new and old operators and technicians must acquaint themselves as quickly as possible with these new standards to avoid possible confusion as the new circuit and tube symbols appear. A complete list of the new symbols is included in the appendix for the convenience of our readers.

All new readers of this text should bear in mind that "Radio Operating Questions and Answers" has not been prepared as a textbook but rather as a review for readers who are already trained in radio communication and whose requirements are a quick review of essential theory, arithmetic, and diagrams. Those students who need basic instruction rather than a review are advised to resort to resident or home-study schools specializing in basic radio-communication and broadcasting courses, and in several complete textbooks on the subject now available. The authors' "Practical Radio Communication" is typical of the type of book required. "Radio Operating Questions and Answers" is believed an excellent adjunct for resident and home-study courses. In this connection it may serve as a guide to the extent of theoretical content requirements in the radio-operating license examinations. It may well be used by teachers to plan a specialized course of instruction in their appropriate branches of radio operating curriculums.

J. L. HORNUNG.

VALLEY STREAM, N.Y.,  
*October, 1946.*

## PREFACE TO THE FIRST EDITION

This book is written especially for students and operators who are about to take the government examination for a radio operator's license.

The material contained herein has been drawn from many sources, carefully chosen and compiled from the commercial radio operator's standpoint. While the reader may not be willing to accept the text as sufficient in all points, it must be remembered that there are many ways of answering questions, and as all viewpoints cannot be taken in a work of this kind, the one considered most expedient was chosen. It is assumed that the reader understands radio operating and theory completely and that this book will merely serve to bring out certain salient points as well as to show the general form of answering questions of this kind.

In conclusion, let me caution all applicants who take the radio operator's license examination to answer all questions fully, never using *et cetera* to explain a meaning. **Do not be brief.**

ARTHUR R. NILSON.

NEW YORK CITY,  
*December, 1921.*



## HOW TO USE THIS BOOK

Many old-time students of radio and many uninformed new students will need to approach radio-operator license preparation from a new viewpoint. Prior to July, 1939, when the so-called "new" examinations went into effect, preparation for a radio-operator license examination consisted mostly of learning the answers to certain standard well-known questions, the answers to which were easily available in published form to anyone. The disadvantages of this system were apparent to the examiners and to others who felt that the government examinations should be a real test of the applicant's knowledge and not a test of his ability to memorize answers. The revised examination procedure was evolved to correct this condition.

Under the new plan a publication entitled "Study Guide and Reference Material for Commercial Radio Operator Examinations" was issued by the Federal Communications Commission. In that book there was presented to the radio-license applicant approximately 1,300 questions covering the entire scope of knowledge required of licensed radio operators. It is to be noticed that only the *scope* of the required knowledge was therein made available to all interested persons.

On the basis of this scope of knowledge a series of multiple-choice-type examinations was prepared from which certain sheets are selected to constitute an examination. Thus a great number of different examinations are available, all covering the same scope of knowledge. The student of this book should not be surprised, therefore, if the questions he meets on the examination are worded differently or approach the subject from a different angle from that given in the answers herein. For example, Question 74 in Element 5 in the FCC's Study Guide reads, "Describe a superregenerative receiver." Obviously a multiple-choice question could not be worded similarly. Instead, the multiple-choice question might read, "What is the

## HOW TO USE THIS BOOK

purpose of the quench frequency?" This would be followed by five answers from which the correct answer must be picked. The applicant whose radio education and preparation have been guided by the Study Guide basic question, "Describe a superregenerative receiver," and the answer as given herein should have no difficulty with this question.

To continue the illustrations, for example, Question 190 in Element 2 in the FCC's Study Guide reads, "Why is a 45-volt dry-cell B battery generally considered unsatisfactory for use when the terminal voltage has fallen to approximately 36 volts?" The multiple-choice question on the examination *may* read, "A partly run down B battery in a receiver will most probably cause [and then follow five items from which the correct answer must be chosen]. However, a well-trained radio-man should have no difficulty in picking out the correct answer.

It is evident, therefore, that the questions in the FCC's Study Guide and their answers as given herein are, as the name of their source book implies, merely a guide to study. They are not intended to be replicas of the actual questions that the applicant will meet on the examination. Whereas the actual number of study-guide questions provided by the FCC totals almost 1,300, it is possible that there may be three or four times that number available on the actual examinations.

It is hoped that the readers of this book will use it for what it was intended, as a review of technical radio information for radio-operator license examination preparation or any similar purpose. The man who has a good basic training in radio communication will find this book invaluable for reference and review purposes according to the testimony of a very great many satisfied readers.

THE AUTHORS.

## CONTENTS

	PAGE
<i>Preface to the Eighth Edition</i> . . . . .	v
<i>Preface to the First Edition</i> . . . . .	vii
<i>How to Use This Book</i> . . . . .	ix
<b>ELEMENT</b>	
1. Basic Radio Laws . . . . .	1
2. Basic Theory and Practice . . . . .	18
3. Radiotelephone . . . . .	114
4. Advanced Radiotelephony . . . . .	178
5. Radiotelegraph . . . . .	248
6. Advanced Radiotelegraphy . . . . .	302
Appendix I. Operating Abbreviations, etc. . .	361
Appendix II. Rules Governing Commercial Radio Operators . . . . .	373
Appendix III. Extracts from Radio Laws . . .	383
Appendix IV. ASA Standard Symbols . . . . .	395
<i>Index of Diagrams and Illustrations</i> . . . . .	411
<i>Index of Subjects</i> . . . . .	415



# RADIO OPERATING QUESTIONS AND ANSWERS

## ELEMENT 1

### BASIC RADIO LAWS

**Ques. 101.01.<sup>1</sup>** Under what conditions may a distress message be retransmitted?

*Ans.* Any station which becomes aware that a mobile station is in distress may transmit the distress message in the following cases:

1. When the station in distress is not itself in a position to transmit the message.
2. In the case of mobile stations, when the master or the person in charge of the ship, aircraft, or other vehicle carrying the station which intervenes believes that further help is necessary.
3. In the case of other stations, when directed to do so by the station in control of distress traffic or when it has reason to believe that a distress call which it has intercepted has not been received by any station in a position to render aid.

**Ques. 101.02.** What tolerance in operating power is permissible under normal circumstances?

*Ans.* The operating power of all radio stations shall be maintained within the following tolerance of the assigned power:

<sup>1</sup> In the government publication, "Study Guide and Reference Material for Commercial Radio Operator Examinations," Ques. 101.01 to 101.05, inclusive, appear at the end of Element 1 instead of at the beginning.

## *RADIO OPERATING QUESTIONS AND ANSWERS*

1. When the maximum power only is specified, the operating power shall not be greater than necessary to carry on the service and in no event more than 5 per cent above the maximum power specified.
2. When an exact power is specified, the operating power shall not be more than 5 per cent above or less than 10 per cent below such power.

**Ques. 101.03.** Under what conditions may a station be operated in a manner other than that specified in the station license?

*Ans.* The licensee of any station, except amateurs, may, during a period of emergency in which the normal communication facilities are disrupted as a result of hurricane, flood, earthquake, or similar disaster, authorize such station for emergency communication service in communicating in a manner other than that specified in the station license, provided (1) that as soon as possible after the beginning of such emergency use notice be sent to the Federal Communications Commission (FCC) in Washington, D. C., and to the Inspector in Charge of the district in which the station is located stating the nature of the emergency and the use to which the station is being put, and (2) that the emergency use of the station shall be discontinued as soon as substantially normal communication facilities are again available and the Commission in Washington, D. C., and the Inspector in Charge be notified immediately when such special use of the station is terminated. The Commission may at any time order the discontinuance of such service.

**Ques. 101.04.** What is the Commission's rule with respect to measurement of the radio station frequency?

*Ans.* The licensee of each station shall provide means for the measurement of the station frequency. The measurement of the station frequency shall be made by a means independent of the frequency control of the transmitter and shall be

conducted in accord with the regulations governing the class of station concerned.

**Ques. 101.05.** When may operation be resumed after a station has been notified to cease transmission because of interference to distress traffic?

*Ans.* No station having been notified to cease operation shall resume operation on frequency or frequencies which may cause interference until notified by the station issuing the original notice that the station involved will not interfere with distress traffic as it is then being routed or until the receipt of a general notice that the need for handling distress traffic no longer exists.

**Ques. 111.01.** State five grounds on any one of which the FCC has authority to suspend a radio operator's license or permit.

*Ans.* The FCC has authority to suspend the license of any operator upon proof sufficient to satisfy the Commission that the licensee—

1. Has violated any provision of any act, treaty, or convention binding on the United States, which the Commission is authorized to administer, or any regulation made by the Commission under any such act, treaty, or convention; or

2. Has failed to carry out a lawful order of the master or person lawfully in charge of the ship or aircraft on which he is employed; or

3. Has willfully damaged or permitted radio apparatus or installations to be damaged; or

4. Has transmitted superfluous radio communications or signals or communications containing profane or obscene words, language, or meaning, or has knowingly transmitted—

*a.* False or deceptive signals or communications, or

*b.* A call signal or letter which has not been assigned by proper authority to the station he is operating; or

5. Has willfully or maliciously interfered with any other radio communications or signals; or
6. Has obtained or attempted to obtain, or has assisted another to obtain or attempt to obtain, an operator's license by fraudulent means.

**Ques. 111.02.** Is an operator subject to the penal provisions of the Act if he violates the terms of a radio treaty to which the United States is a party?

*Ans.* Any person who willfully and knowingly violates any rule, regulation, restriction, or condition made or imposed by the Commission under authority of this Act, or any rule, regulation, restriction, or condition made or imposed by any international radio or wire communications treaty or convention, or regulations annexed thereto, to which the United States is or may hereafter become a party, shall, in addition to any other penalties provided by law, be punished, upon conviction thereof, by a fine of not more than \$500 for each and every day during which such offense occurs.

**Ques. 111.03.** State at least two provisions made in the Communications Act to ensure the priority of communications or signals relating to ships in distress.

*Ans.* All radio stations, including Government stations and stations on board foreign vessels when within the territorial waters of the United States, shall give absolute priority to radio communications or signals relating to ships in distress; shall cease all sending on frequencies which will interfere with hearing a radio communication or signal of distress, and, except when engaged in answering or aiding the ship in distress, shall refrain from sending any radio communications or signals until there is assurance that no interference will be caused with the radio communications or signals relating thereto, and shall assist the vessel in distress, as far as possible, by complying with its instructions.

Stations in the mobile service shall be obliged to accept, with absolute priority, distress calls and messages regardless of their origin, to reply to them in the same manner, and to take any necessary action on them immediately.

**Ques. 111.04.** In what class of radio station and under what conditions is an operator permitted to adjust the transmitter for a maximum of radiation without regard to the interference produced?

*Ans.* The transmitting set in a radio station on shipboard may be adjusted in such a manner as to produce a maximum of radiation, irrespective of the amount of interference which may thus be caused, when such station is sending distress communications or signals or communications relative thereto.

**Ques. 111.05.** In what cases may a transmitter on shipboard be adjusted to produce a maximum of radiation irrespective of the interference which may be caused?

*Ans.* (See answer to Ques. 111.04.)

**Ques. 121.01.** What communications, if any, are not subject to the secrecy provisions of the Communications Act?

*Ans.* Any radio communication broadcast, or transmitted by amateurs or others for the use of the general public, or relating to ships in distress.

**Ques. 121.02.** State in your own words the prohibition, if any, against the transmission of false calls and communications relating to distress.

*Ans.* No person within the jurisdiction of the United States shall knowingly utter or transmit, or cause to be uttered or transmitted, any false or fraudulent signal of distress, or communication relating thereto.

**Ques. 121.03.** State in your own words the law regarding the transmission of false or fraudulent signals of distress or communications relating thereto.

*Ans.* (See preceding answer for basic law.)

**Ques. 121.04.** State in your own words the substance of the Communications Act that is provided to ensure the secrecy of radiograms.

*Ans.* In general the law provides that no one receiving a radio or wire message not intended for the public shall divulge it to anyone except the addressee or his authorized agent or to another station for forwarding, unless required to do so by a court of competent jurisdiction, and no one not entitled to it shall receive any radio or wire communication and use it for his own benefit. The penalty is a fine not exceeding \$10,000 or imprisonment for a term not exceeding 2 years, or both.

**Ques. 121.05.** Does the Communications Act of 1934, as amended, contain any provision that prohibits the interception, use, and publication of radio communications?

*Ans.* Yes. (See answer to Ques. 121.04 for basic law.)

**Ques. 131.01.** What form of language if transmitted by an operator or other person makes him subject to the penal provisions of the Communications Act?

*Ans.* Nothing in this Act shall be understood or construed to give the Commission the power of censorship over the radio communications or signals transmitted by any radio station, and no regulation or condition shall be promulgated or fixed by the Commission which shall interfere with the right of free speech by means of radio communication. No person within the jurisdiction of the United States shall utter any obscene, indecent, or profane language by means of radio communication.

**Ques. 131.02.** What provisions are made in the Communications Act to ensure intercommunication between stations in the mobile service?

*Ans.* Every land station open to general public service between the coast and vessels or aircraft at sea shall, within the scope of its normal operations, be bound to exchange radio communications or signals with any ship or aircraft station at sea; and each station on shipboard or aircraft at sea shall, within the scope of its normal operations, be bound to exchange radio communications or signals with any other station on shipboard or aircraft at sea or with any land station open to general public service between the coast and vessels or aircraft at sea: PROVIDED, That such exchange of radio communication shall be without distinction as to radio systems or instruments adopted by each station.

**Ques. 131.03.** Does the FCC have authority to issue a radio operator's license or permit to a citizen of a country other than the United States?

*Ans.* No.

**Ques. 131.04.** Has the master of a ship radiotelephone station the authority to forbid the transmission of a message by anyone on board?

*Ans.* Yes. The radio installation, the operators, the regulation of their watches, the transmission and receipt of messages, and the radio service of the ship, except as they may be regulated by law or international agreement, or by rules and regulations made in pursuance thereof, shall in the case of a ship of the United States be under the supreme control of the master.

**Ques. 131.05.** Has the master of a ship station the authority to regulate the transmissions and reception of messages on shipboard?

*Ans.* Yes. (See preceding answer for basic law.)

**Ques. 131.06.** Under what conditions is the utterance or transmission of a false or fraudulent signal of distress or communications relating thereto permissible?

## *RADIO OPERATING QUESTIONS AND ANSWERS*

*Ans.* (See answer to Ques. 121.02 for basic law.)

**Ques. 131.07.** Under what conditions is the utterance of obscene, indecent, or profane language by means of radio communication permissible?

*Ans.* Under no conditions. (See answer to Ques. 131.01 for basic law.)

**Ques. 141.01.** What is the radiotelephony safety signal?

*Ans.* In radiotelephony, the word SECURITY (corresponding to the French pronunciation of the word *sécurité*) repeated three times shall be used as the safety signal.

**Ques. 141.02.** Under what conditions may a mobile station, if necessary, disregard the General Radio Regulations (Cario)?

*Ans.* No provision of these Regulations shall prevent a mobile station in distress from using any means available to it for drawing attention, signaling its position, and obtaining help.

**Ques. 141.03.** What is the radiotelephony urgent signal?

*Ans.* In radiotelephony the urgent signal shall consist of three transmissions of the expression PAN (corresponding to the French pronunciation of the word *panne*); it shall be transmitted before the call.

**Ques. 141.04.** What signals and messages are forbidden by international agreement?

*Ans.* The transmission of unnecessary or unidentified signals or correspondence shall be forbidden to all stations.

**Ques. 141.05.** What precaution must an operator observe before proceeding with a transmission?

*Ans.* Before transmitting, any station must keep watch over a sufficient interval to assure itself that it will cause no

harmful interference with the transmissions being made within its range; if such interference is likely, the station shall await the first stop in the transmission which it may disturb.

**Ques. 141.06.** What does the receipt of the signal PAN transmitted by radiotelephony indicate?

*Ans.* The urgent signal (PAN) shall indicate that the calling station has a very urgent message to transmit concerning the safety of a ship, an aircraft, or another vehicle, or concerning the safety of some person on board or sighted from on board.

**Ques. 141.07.** What should an operator do if he intercepts the word SECURITY repeated three times?

*Ans.* All stations hearing the safety signal must continue listening on the wave on which the safety signal has been sent until the message so announced has been completed; they must moreover keep silence on all waves likely to interfere with the message.

**Ques. 141.08.** Under what circumstances may the signal SECURITY be transmitted in radiotelephony?

*Ans.* The safety signal (SECURITY) announces that the station is about to transmit a message concerning the safety of navigation or giving important meteorological warnings. Hence, it should precede such a transmission.

**Ques. 141.09.** The urgent signal sent by an aircraft and not followed by a message indicates what?

*Ans.* In the aeronautical service, the urgent signal PAN shall be used in radiotelegraphy and in radiotelephony to indicate that the aircraft transmitting it is in trouble and is forced to land, but that it is not in need of immediate help. This signal should, as far as possible, be followed by a message giving additional information.

## *RADIO OPERATING QUESTIONS AND ANSWERS*

**Ques. 141.10.** What obligation rests on an operator intercepting the signal PAN?

*Ans.* The urgent signal shall have priority over all other communications, except distress communications, and all mobile or land stations hearing it must take care not to interfere with the transmission of the message which follows the urgent signal.

**Ques. 151.01.** What procedure must be followed by a radio station receiving a distress call from a mobile station which is unquestionably in its vicinity?

*Ans.* Stations of the mobile service which receive a distress message from a mobile station which is unquestionably in their vicinity, must acknowledge receipt thereof at once. If the distress call has not been preceded by an auto-alarm signal, these stations may transmit this auto-alarm signal with the authorization of the authority responsible for the station, taking care not to interfere with the transmission of the acknowledgment of the receipt of said message by other stations.

**Ques. 151.02.** What essential information should be transmitted in a distress message?

*Ans.* The distress call must be followed as soon as possible by the distress message. This message shall include the distress call followed by the name of the ship, aircraft, or the vehicle in distress, information regarding the position of the latter, the nature of the distress and the nature of the help requested, and any other further information which might facilitate this assistance.

**Ques. 151.03.** By what authority may the operator of a ship or aircraft station transmit a distress call or message?

*Ans.* The distress call and message shall be sent only by order of the master or person responsible for the ship, aircraft, or other vehicle carrying the mobile station.

**Ques. 151.04.** What is the international distress signal to be used in radiotelephony?

*Ans.* In radiotelephony, the distress signal shall consist of the spoken expression MAYDAY (corresponding to the French pronunciation of the expression *m'aider*).

**Ques. 151.05.** What does the interception of the word MAYDAY transmitted by telephony announce?

*Ans.* These distress signals shall announce that the ship, aircraft, or any other vehicle which sends the distress signal is threatened by serious and imminent danger and requests immediate assistance.

**Ques. 151.06.** What radio waves may be used under the provisions of the Treaty in transmitting distress messages in case of an emergency by aircraft stations?

*Ans.* Any aircraft in distress must transmit the distress call on the watching wave of the land or mobile stations capable of helping it; when the call is addressed to stations of the maritime service, the waves to be used are the distress wave or watching wave of these stations.

**Ques. 151.07.** State the priority of radio communications in the mobile service.

*Ans.* The order of priority of radio communications in the mobile service shall be as follows:

1. Distress calls, distress messages, and distress traffic.
2. Communications preceded by an urgent signal.
3. Communications preceded by a safety signal.
4. Communications relative to radio direction-finding bearings.
5. Government radiotelegrams for which priority right has not been waived.
6. All other communications.

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 151.08.** What information must be contained in a distress message transmitted in an emergency, from a radio station aboard aircraft flying over land?

*Ans.* As a general rule, an aircraft flying over land shall signal its position by the name of the nearest locality, its approximate distance from this point, accompanied according to the case, by one of the words NORTH, SOUTH, EAST, or WEST, or, in some cases, words indicating intermediate directions.

**Ques. 151.09.** What information must be contained in a distress message?

*Ans.* (See answer to Ques. 151.02 for basic law.)

**Ques. 151.10.** When, after having sent its distress message, an aircraft station is unable to signal its position, what procedure shall be followed to assist others in determining its approximate location?

*Ans.* When, in its distress message, an aircraft is unable to signal its position, it shall endeavor after the transmission of the incomplete message to send its call signal long enough so that the radio direction-finding stations may determine its position.

**Ques. 161.01.** State at least two classes of stations which cannot be operated by the holder of a restricted radiotelephone operator permit.

*Ans.* Standard Broadcast Stations and ship stations aboard compulsorily equipped ships.

**Ques. 161.02.** Under what conditions may the holder of a restricted radiotelephone operator's permit operate a station for which the permit is valid?

*Ans.* The holder of a restricted radiotelephone operator's permit may operate any station while using type A0, A3, or A4 emission; provided that—

1. Such operator is prohibited from making adjustments that may result in improper transmitter operation.
2. The equipment is so designed that none of the operations necessary to be performed during the course of normal rendition of service may cause off-frequency operation or result in any unauthorized radiation.
3. Any needed adjustments of the transmitter that may affect the proper operation of the station are regularly made by or in the presence of an operator holding a first- or second-class license, either telephone or telegraph, who shall be responsible for the proper operation of the equipment.

**Ques. 161.03.** State at least two classes of ship stations which the holder of a restricted radiotelegraph operator permit is prohibited from operating.

*Ans.* The permit is not valid for the operation of a ship station licensed to use type A3 emission for communication with coastal telephone stations.

The license [permit] is not valid for the operation of a radiotelegraph station on board a vessel required by treaty or statute to be equipped with a radio installation.

**Ques. 161.04.** Who is permitted to make adjustments or tests in the presence of the licensed operator responsible for the maintenance of the transmitter and under his responsibility for the proper operation of the equipment?

*Ans.* The licensed operator responsible for the maintenance of a transmitter may permit other persons to adjust a transmitter in his presence for the purpose of carrying out tests or making adjustments requiring specialized knowledge or skill, provided that he shall not be relieved thereby from responsibility for the proper operation of the equipment.

**Ques. 161.05.** Within what period of time must any person receiving official notice of a violation of the terms of the Com-

**munications Act of 1934, as amended, Treaty, or Rules and Regulations of the Commission be answered?**

*Ans.* Within 3 days.

**Ques. 171.01. What is the obligation of an operator whose license or permit has been lost, mutilated, or destroyed?**

*Ans.* An operator whose license or permit has been lost, mutilated, or destroyed shall immediately notify the Commission. A sworn application for duplicate should be submitted to the office of issue embodying a statement attesting to the facts thereof. If a license has been lost, the applicant must state that reasonable search has been made for it, and further, that in the event it be found either the original or the duplicate will be returned for cancellation. The applicant must also give a statement of the service that has been obtained under the lost license.

**Ques. 171.02. How may the holder of a radiotelegraph or radiotelephone first- or second-class license indicate to representatives of the Commission that he is legally qualified to adjust equipment operated by holders of restricted radiotelephone operator permits?**

*Ans.* The holder of a radiotelegraph or radiotelephone first- or second-class license who is employed as a service and maintenance operator at stations operated by holders of restricted operator permits shall post at such station his operator license or a verified statement from the Commission in lieu thereof.

**Ques. 171.03. How may an operator show proof of his legal qualifications to operate a radio transmitter?**

*Ans.* The original license of each station operator shall be posted at the place where he is on duty or kept in his possession in the manner specified in the regulations governing the class of station concerned.

**Ques. 171.04.** What is an operator of a radio station, who has submitted his license for renewal or applied for a duplicate license, required to exhibit as his authority to continue operation on the station, pending receipt of the license?

*Ans.* When a duplicate operator license or permit has been requested, or request for renewal upon service has been made, the operator shall exhibit in lieu thereof a signed copy of the application for duplicate, or renewal, which has been submitted by him.

**Ques. 171.05.** What is the holder of a radiotelegraph or radiotelephone first- or second-class license, who is employed as a service and maintenance operator at stations operated by holders of restricted operator permits, obligated to post at the stations?

*Ans.* (See answer to Ques. 171.02 for rule.)

**Ques. 181.01.** How may corrections be made in a log?

*Ans.* Any necessary correction may be made only by the person originating the entry who shall strike out the erroneous portion, initial the correction made, and indicate the date of correction.

**Ques. 181.02.** Is it lawful to erase an entry made in a station log?

*Ans.* No log or portion thereof shall be erased, obliterated, or willfully destroyed within the period of retention provided by the rules.

**Ques. 181.03.** What are the Commission's requirements with regard to the retention of a radio station log?

*Ans.* Logs of a radio station, when required in the rules and regulations to be made or kept, shall be retained by the licensee for a period of one year unless otherwise provided by the rules governing the particular service or class of station concerned.

## *RADIO OPERATING QUESTIONS AND ANSWERS*

**Ques. 181.04.** How long must the licensee retain a station log which involves communications incident to a disaster?

*Ans.* Logs involving communications incident to a disaster or which include communications incident to or involved in an investigation by the Commission and concerning which the licensee has been notified, shall be retained by the licensee until specifically authorized in writing by the Commission to destroy them: PROVIDED, FURTHER, That logs incident to or involved in any claim or complaint of which the licensee has notice shall be retained by the licensee until such claim or complaint has been fully satisfied or until the same has been barred by statute limiting the time for the filing of suits upon such claims.

**Ques. 181.05.** What is the Commission's rule with regard to rough logs?

*Ans.* Rough logs may be transcribed into condensed form, but in such case the original log or memoranda and all portions thereof shall be preserved and made a part of the complete log.

**Ques. 191.01.** What procedure should one follow if he desires to resist an order of suspension of his operator's license or permit?

*Ans.* Make written application to the Commission at any time within 15 days for a hearing upon the order of suspension.

**Ques. 191.02.** What is the responsibility of a licensee of a radio station with respect to permitting it to be inspected by representatives of the Commission?

*Ans.* The licensee of any radio station shall make the station available for inspection by representatives of the Commission at any reasonable hour and under the regulations governing the class of station concerned.

**Ques. 191.03.** Who is responsible for the control of distress traffic?

*Ans.* The control of distress traffic shall devolve upon the mobile station in distress or upon the station which by application of the provisions . . . [See Ques. 101.01] has sent the distress call. These stations may delegate the control of the distress traffic to another station.

**Ques. 191.04.** Are logs subject to inspection by representatives of the Commission?

*Ans.* Yes. (See answer to next question.)

**Ques. 191.05.** By whom may the log of a radio station be kept?

*Ans.* Each log shall be kept by the person or persons competent to do so, having actual knowledge of the facts required, who shall sign the log when starting duty and again when going off duty. The logs shall be made available upon request by an authorized representative of the Commission.

## ELEMENT 2

### BASIC THEORY AND PRACTICE

**Ques. 2.01.** By what other expression may a “difference of potential” be described?

*Ans.* By various terms as follows: e.m.f.; voltage;  $IR$  drop; voltage drop; fall of potential.

**Ques. 2.02.** By what other expression may an “electric current flow” be described?

*Ans.* Electric current flow may be described as an electron flow, or referred to as the *amperage* in the circuit.

**Ques. 2.03.** Which factors determine the amplitude of the e.m.f. induced in a conductor which is cutting lines of magnetic force?

*Ans.* 1. Speed of cutting; 2. Flux density; 3. The relative angle between direction of motion of conductor and direction of magnetic flux.

Maximum e.m.f. is generated when the velocity is maximum and the relative angle is 90 degrees.

**Ques. 2.04.** Name four methods by which an electrical potential may be generated.

- Ans.* 1. Chemical (battery).
- 2. Mechanical (generator).
- 3. Heat (thermocouple).
- 4. Friction (static charge).
- 5. Pressure and Expansion (piezoelectric).
- 6. Light (photo electric cell).

**Ques. 2.05.** If the diameter of a conductor of given length is doubled, how will the resistance be affected?

**Ans.** The resistance of a wire varies inversely with its cross-section or end area, and varies directly as the reciprocal of the cross-section or end area. The end area equals  $0.7854 \times \text{diameter squared}$ . Hence, if the diameter is doubled, the resistance is only one-fourth as great as before. If the diameter is tripled, the resistance is only one-ninth as great as before. Thus, it is apparent that the resistance of a wire varies directly as the reciprocal of the diameter squared.

**Ques. 2.06.** If the value of a resistance, to which a constant e.m.f. is applied, is halved, what will be the resultant proportional power dissipation?

**Ans.** The power dissipation will be doubled.

$$\text{Power} = I^2R; \quad \frac{E^2}{R}$$

assuming a voltage of 1 volt and a resistance of 1 ohm, in applying Ohm's law we get a current of 1 ampere. On the same basis, we get a power dissipation of 1 watt. If, now, the resistance is cut in half, we will double the current to 2 amperes. The power, then, will equal 2 watts.

**Ques. 2.07.** What method of connection should be used to obtain the maximum no-load output voltage from a group of similar cells in a storage battery?

**Ans.** Series connection.

**Ques. 2.08.** What is the sum of all voltage drops around a simple direct-current series circuit, including the source?

**Ans.** According to Kirchhoff's second law, the sum of all voltage drops around a simple direct-current circuit, including the source, is zero. This answer is arrived at by considering the voltage drop within the generating device to be a negative

## *RADIO OPERATING QUESTIONS AND ANSWERS*

value and that in the external resistance a positive value, and adding the two values algebraically.

**Ques. 2.09.** What method of connection should be used to obtain the maximum short-circuit current from a group of similar cells in a storage battery?

*Ans.* Parallel connection.

**Ques. 2.10.** If the value of a resistance, across which a constant e.m.f. is applied, is doubled, what will be the resultant proportional power dissipation?

*Ans.* The power dissipation will be cut in half. (This conclusion is arrived at by following the reasoning explained in the answer to Ques. 2.06.)

**Ques. 2.11.** Name four materials which are good insulators at radio frequencies. Name four materials which are not good insulators at radio frequencies, but which are satisfactory for use at commercial power frequencies.

*Ans.* Good radio-frequency insulators: quartz, steatite bodies, polythene, polymerized styrene, Pyrex, Mycalex.

Good commercial power-frequency insulators: cellulose, asbestos, slate, fiber, glass, porcelain, rubber.

**Ques. 2.12.** Explain the factors which influence the resistance of a conductor.

*Ans.* The factors which influence the resistance of a conductor are the cross-section or end area of the conductor, the character of the conducting material, the length of the conductor, and the ambient temperature.

**Ques. 2.13.** What effect does the cross-section area of a conductor have upon its resistance per unit length?

*Ans.* The resistance per unit length is inversely proportional to the cross section of the conductor, and varies directly as the reciprocal of the cross-section or end area. Example:

If the end area is doubled, the resistance is cut in half; if the end area is tripled, the resistance is only one-third of the original value.

**Ques. 2.14.** Name four conducting materials in the order of their conductivity.

*Ans.* Silver, copper, aluminum, and zinc.

**Ques. 2.15.** What effect does a change in the dielectric constant of a condenser dielectric material have upon the capacitance of a condenser?

*Ans.* Condenser capacity varies directly as the dielectric constant.

**Ques. 2.16.** Explain the effect of increasing the number of plates upon the capacitance of a condenser.

*Ans.* Increasing the number of plates will increase the capacitance of a condenser.

**Ques. 2.17.** State the formula to determine the capacitative reactance of a condenser.

*Ans.*

$$X_c = \frac{1}{2\pi f C} \text{ ohms,}$$

where  $C$  is in farads

$$X_c = \frac{10^6}{2\pi f C} \text{ ohms,}$$

where  $C$  is in microfarads.

**Ques. 2.18.** If the specific inductive capacity of a condenser dielectric material between the condenser plates were changed from 1 to 2, what would be the resultant change in capacitance?

*Ans.* The capacitance would be doubled.

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 2.19.** State the formula for determining (1) the amount of electricity a condenser will hold? (2) The energy stored in a condenser?

*Ans.* (1)

$$Q = C \times E$$

where  $C$  is in farads.

$E$  in volts.

$Q$  in coulombs.

Also,

$$E = \frac{Q}{C}$$

(2)  $W = \frac{1}{2} E^2 C = \frac{Q^2}{2C}$ ,

where  $C$  is in farads,  $W$  in joules.

**Ques. 2.20.** Neglecting temperature coefficient of resistance and using the same gauge of wire and the same applied voltage in each case, what would be the effect, upon the field strength of a single layer solenoid, of a small increase in the number of turns?

*Ans.* An increase in the number of turns will increase the resistance and decrease the current. The effect on field strength of the decreased current is exactly balanced by the increased number of turns with the result that the field strength is practically unchanged.

**Ques. 2.21.** How will a magnetic compass be affected when placed within a coil carrying an electric current?

*Ans.* The north pole of the compass will move toward the north pole of the coil, taking a position at right angles to the current flow.

**Ques. 2.22.** What material should be used for shielding a radio-frequency magnetic field?

*Ans.* Copper, aluminum, or brass—always a low-resistance metal.

**Ques. 2.23.** What is the advantage to be gained by bank winding an inductance?

*Ans.* Bank winding an inductance decreases the total distributed capacity of the coil.

**Ques. 2.24.** Which factors influence the direction of magnetic lines of force generated by an electromagnet?

*Ans.* The magnetic lines of force generated by an electromagnet will take a direction determined by the direction of the windings of the solenoid and the direction of current flow through the coil.

**Ques. 2.25.** Explain the meaning of and factors which determine the *Q* or "figure of merit" of an inductance.

*Ans.* The following factors affect the *Q* of an inductance:

1. Frequency.
2. Inductance value.
3. Ohmic resistance.
4. Effective high-frequency resistance.
5. Method of winding.
6. Distributed capacity.
7. Dielectric losses in the coil form.
8. Permeability of core.

The *Q* of an inductance is the ratio of the apparent inductive reactance of the coil to its effective resistance. The formula is  $Q = \frac{X}{R}$ .

**Ques. 2.26.** Define the term "permeability."

*Ans.* "Permeability" may be defined as the ratio of the ability of a magnetic material to conduct magnetic lines of force to the ability of air to conduct the same lines.

**Ques. 2.27.** What unit is used in expressing the alternating current impedance of a circuit?

## RADIO OPERATING QUESTIONS AND ANSWERS

*Ans.* The ohm.

**Ques. 2.28.** What is the unit of resistance?

*Ans.* The ohm.

**Ques. 2.29.** Explain the meaning of the prefix in "micro-microfarad."

*Ans.* The prefix "micromicro" means one trillionth or  $10^{-12}$ .

**Ques. 2.30.** What is the unit of capacitance?

*Ans.* The standard unit is the farad. For practical purposes the unit of capacitance is nearly always expressed in microfarads or micromicrofarads, meaning one-millionth or one-trillionth of a farad, respectively.

**Ques. 2.31.** What single instrument may be used to measure (1) electrical resistance? (2) Electrical power? (3) Electrical current? (4) Electromotive force?

*Ans.* 1. Electrical resistance can be measured by using a voltmeter and a standard resistor (ohmmeter). Resistance may also be measured, but less accurately, by using a voltmeter whose resistance is known and applying the formula

$$R = \frac{E_1 - E_2}{E_2} \times R_m,$$

where  $E_1$  is the voltage without the unknown resistor in the circuit.

$E_2$  is the voltage with the unknown resistor in the circuit.

$R_m$  is the resistance of the voltmeter.

2. Electrical power is measured by a wattmeter.
3. Electrical current is measured by an ammeter.
4. Electromotive force is measured by a voltmeter.

**Ques. 2.32.** Define the term "residual magnetism."

*Ans.* "Residual magnetism" is the magnetism remaining in a material after the magnetizing force has been removed and the material is in a free state.

**Ques. 2.33. What is the unit of electrical power?**

*Ans.* The watt.

**Ques. 2.34. What is the unit of conductance?**

*Ans.* The mho.

**Ques. 2.35. What is the unit of inductance?**

*Ans.* The standard unit is the henry. For practical purposes, the unit of inductance is sometimes expressed in millihenrys or microhenrys, meaning one-thousandth or one-millionth of a henry, respectively.

**Ques. 2.36. What is the meaning of the prefix "kilo"?**

*Ans.* "Kilo" as a prefix means one thousand; thus, when compounded with other words, it means multiply by one thousand.

**Ques. 2.37. What is the meaning of the prefix "micro"?**

*Ans.* "Micro" as a prefix means one-millionth; thus, when compounded with other words, it means one-millionth part of the whole.

**Ques. 2.38. What is the meaning of "power factor"?**

*Ans.* "Power factor" is the ratio of the resistance to the impedance in an alternating-current circuit. Power factor is also the ratio of the true watts, as indicated by a wattmeter, to the apparent watts, as indicated by a voltmeter and ammeter, in the circuit. The power factor is always less than one and is found by the following formulas:

$$P.F. = \frac{R}{Z}; \quad P.F. = \frac{W}{EI}; \quad P.F. = \cos \theta$$

## RADIO OPERATING QUESTIONS AND ANSWERS

Power factor is an indirect measure of the quality of an alternating-current circuit or power-consuming device.

**Ques. 2.39. What is the meaning of the prefix "meg.?"**

*Ans.* "Meg" is short for *mega*, meaning one million; compounded with other words, it means one million times the original quantity or  $10^6$ .

**Ques. 2.40. Define the term "conductance."**

*Ans.* "Conductance" is the reciprocal of the resistance in direct-current circuits. In alternating-current circuits, conductance is the ratio of the resistance to the impedance squared, expressed in mhos. From a practical viewpoint, conductance is the ability of a circuit to conduct current.

**Ques. 2.41. What instrument is used to measure current flow?**

*Ans.* Electrical current flow is measured by an ammeter.

**Ques. 2.42. Define the term "decibel."**

*Ans.* The "decibel" (db) is the unit used for expressing the ratio between two quantities, of either electrical or sound energy. The unit, decibel, is a relative measurement of electrical or sound energy levels and does not specify any definite current, voltage, or power. Using conventional symbols, the formulas for the decibel are as follows:

$$\text{db} = 10 \log_{10} \frac{P_1}{P_2}, \quad \text{db} = 20 \log_{10} \frac{E_1}{E_2}, \quad \text{db} = 20 \log_{10} \frac{I_1}{I_2}.$$

**Ques. 2.43. What is meant by "ampere turns"?**

*Ans.* "Ampere turns" = number of turns  $\times$  current.

**Ques. 2.44. Define the term "inductance."**

*Ans.* "Inductance" is that characteristic of a circuit which permits an e.m.f. to be induced in it when it, the circuit, is cut

by magnetic lines of force. The polarity of the induced e.m.f. is such as to oppose the force that produced it.

**Ques. 2.45. Define the term "coulomb."**

*Ans.* The unit of *quantity* of electricity passing a given point in a conductor in 1 second when 1 ampere is flowing is called a "coulomb." One coulomb is also the amount of electricity contained in a condenser having a capacitance of 1 farad when charged to a potential of 1 volt.

**Ques. 2.46. Define the term "power factor" and give an example of how it relates to power consumed in an alternating-current circuit.**

*Ans.* Assume an alternating-current circuit connected to a source of 100 volts, 25 cycles, has an impedance of 25 ohms. The direct-current resistance is 20 ohms. Find the power consumed and the power factor.

$$I = \frac{E}{R}.$$

$$P = I^2R = (4)^2 \times 20 = 320 \text{ watts.}$$

$$P.F. = \frac{P}{EI} = \frac{320}{100 \times 4} = 0.8.$$

also,

$$\cos \theta = P.F. = \frac{R}{Z} = \frac{20}{25} = 0.8.$$

(See also Ques. 2.38.)

**Ques. 2.47. What is the unit of magnetomotive force?**

*Ans.* The unit of magnetomotive force is the gilbert (*F*). Ampere turns may be changed to gilberts by multiplying by 1.26.

**Ques. 2.48. Express 1 horsepower in watts.**

*Ans.* 1 horsepower = 746 watts.

**Ques. 2.49. State the three ordinary mathematical forms of Ohm's law.**

*Ans.*

$$E = I \times R.$$

$$R = \frac{E}{I}.$$

$$I = \frac{E}{R}.$$

**Ques. 2.50.** State Ohm's law.

*Ans.* The current in an electric circuit varies directly as the e.m.f. producing it and inversely as the resistance of the conductor.

**Ques. 2.51.** If a vacuum tube having a filament rated at  $\frac{1}{4}$  ampere and 5 volts is to be operated from a 6-volt battery, what is the value of the necessary series resistor?

*Ans.* The voltage drop across the filament is 5 volts. Therefore, the voltage drop across the resistor must be 1 volt. Applying Ohm's law, we find that the necessary resistance is 4 ohms, calculated as follows:

$$R = \frac{E}{I} = \frac{1}{0.25} = 4 \text{ ohms.}$$

**Ques. 2.52.** If the voltage applied to a circuit is doubled and the resistance of the circuit is increased to three times its former value, what will be the final current value?

*Ans.* Assuming the initial conditions are as follows: E.m.f. = 1 volt,  $R = 1$  ohm; then the current flow is 1 ampere. If, then, the voltage is doubled to 2 volts and the resistance increased to 3 ohms, the current, according to Ohm's law, will be

$$I = \frac{E}{R} = \frac{2}{3} \text{ ampere,}$$

or two-thirds of the initial value.

**Ques. 2.53.** If a relay is designed to operate properly from a 6-volt direct-current source, and if the resistance of the winding is 120 ohms, what value of resistance should be connected in series with the winding if the relay is to be used with a 120-volt direct-current source?

*Ans.* The resistor must drop the voltage 114 volts. Figuring the current flow in the relay according to Ohm's law, we get 0.05 ampere. This same value of current will also flow through the resistor. Hence, the value of the resistor must be 2,280 ohms, computed as follows:

$$R = \frac{E}{I} = \frac{114}{0.05} = 2,280 \text{ ohms.}$$

**Ques. 2.54.** What should be the minimum power dissipation rating of a resistor of 20,000 ohms to be connected across a potential of 500 volts?

*Ans.* Theoretically, a 12.5-watt resistor would do. In practice, at least a 25-watt resistor would be used. The computations are as follows:

*Solution:*

$$\text{Power} = \frac{E^2}{R} = \frac{500^2}{20,000} = 12.5 \text{ watts.}$$

**Ques. 2.55.** If resistors of 5, 3, and 15 ohms are connected in parallel, what is the total resistance?

*Ans.* 1.66 ohms, computed as follows:

$$R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} = \frac{1}{\frac{1}{5} + \frac{1}{3} + \frac{1}{15}} = \frac{15}{9} = 1.66 \text{ ohms.}$$

**Ques. 2.56.** What is the maximum rated current carrying capacity of a resistor marked "5,000 ohms, 200 watts"?

Ans. 200 milliamperes, computed as follows:

$$I = \sqrt{\frac{W}{R}} = \sqrt{0.04} = 0.2 \text{ ampere.}$$

Ques. 2.57. Show how you would use a wave trap to exclude an undesired radio signal from a receiver.

Ans. See Fig. 2-1.

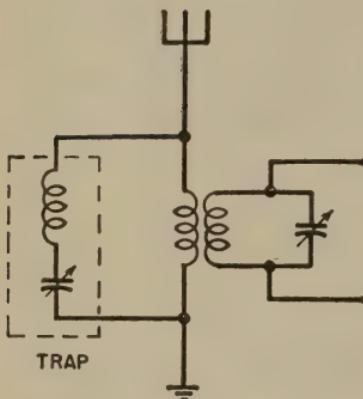


FIG. 2-1.—Simple series resonant wave trap.

Ques. 2.58. A milliammeter with a full-scale deflection of 1 millampere and having a resistance of 25 ohms was used to measure an unknown current by shunting the meter with a 4-ohm resistor. It then read 0.4 millampere. What was the unknown current value?

Ans. Let  $I_1$  equal full-scale current through meter without shunt;  $I_2$  equal full-scale current through shunt;  $R_1$  equal resistance of meter;  $R_2$ , equal resistance of shunt.

Then

$$\frac{I_1}{I_2} = \frac{R_2}{R_1} \quad (\text{Let } I_2 = x.)$$

$$\frac{1}{x} = \frac{4}{25}$$

$$x = 6.25 = I_2.$$

Total current through the meter and shunt equals 7.25 milliamperes with full-scale deflection. With 0.4 deflection, the actual current is  $0.4 \times 7.25 = 2.9$  milliamperes.

Ques. 2.59. What will be the heat dissipation, in watts, of a resistor of 20 ohms having a current of  $\frac{1}{4}$  ampere passing through it?

*Ans.*

$$\begin{aligned}\text{Power} &= I^2R \text{ watts} \\ &= (1/4)^2 \times 20 \\ &= 1/16 \times 20 = 1.25 \text{ watts.}\end{aligned}$$

**Ques. 2.60.** If two 10-watt 500-ohm resistors are connected in parallel, what are the power dissipation capabilities of the combination?

*Ans.* 20 watts.

**Ques. 2.61.** What is the formula used to determine the total capacitance of three or more capacitances connected in series?

*Ans.*

$$C = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \dots}$$

where  $C$  is in the same units, farads or microfarads, as are used to express  $C_1$ ,  $C_2$ ,  $C_3$ , and so forth.

**Ques. 2.62.** What is the formula for determining the capacitative reactance of a condenser?

*Ans.*

$$X_c = \frac{1}{2\pi f C},$$

where  $X_c$  is in ohms.

$f$  in cycles per second.

$C$  in farads.

$$X_c = \frac{10^6}{2\pi f C},$$

where  $C$  is in microfarads.

**Ques. 2.63.** If condensers of 1, 3, and 5 microfarads are connected in parallel, what is the total capacitance?

*Ans.*

$$C = C_1 + C_2 + C_3 = 1 + 3 + 5 = 9 \text{ microfarads.}$$

**Ques. 2.64.** What is the formula used to determine the total capacitance of three or more condensers connected in parallel?

*Ans.*

$$C = C_1 + C_2 + C_3 \dots$$

where  $C$  is in the same units, farads or microfarads, as  $C_1$ ,  $C_2$ ,  $C_3$ , and so forth.

**Ques. 2.65.** If condensers of 5, 3, and 7 microfarads are connected in series, what is the total capacitance?

*Ans.* The total capacitance is 1.48 microfarads, computed as follows:

$$C = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}} = \frac{1}{\frac{1}{5} + \frac{1}{3} + \frac{1}{7}} = \frac{1}{0.676} = 1.48 \text{ microfarads.}$$

**Ques. 2.66.** The charge in a condenser is stored in what portion of the condenser?

*Ans.* On the surface of the dielectric in the form of electrostatic lines of force.

**Ques. 2.67.** Having available a number of condensers rated at 400 volts and 2 microfarads each, how many of these condensers would be necessary to obtain a combination rated at 1,600 volts 1.5 microfarads?

*Ans.* Twelve condensers connected into three series banks of four condensers each, the series banks then being connected in parallel.

**Ques. 2.68.** Calculate the voltage drop across an individual condenser of a group connected in series.

*Ans.* Let  $C_t$  equal the total capacitance,  $C_1$  equal the capacity of one of the condensers,  $E$  equal the potential across the group. Then the voltage across  $C_1$  can be found by

$$C_1 = E \times \frac{C_t}{C_1}$$

**Ques. 2.69.** What factors determine the charge stored in a condenser?

*Ans.* The charging voltage and the condenser capacity. (See Ques. 2.19.)

**Ques. 2.70.** Given two identical mica condensers of 0.1 microfarad capacity, each. One of these is charged to a potential of 125 volts and disconnected from the charging circuit. The charged condenser is then connected in parallel with the uncharged condenser. What voltage will appear across the two condensers connected in parallel?

*Ans.* 62.5 volts. It is obvious that if the capacity is doubled, as will happen when the parallel connection is made, the voltage must distribute itself between two equal capacitances. (For formulas, see Ques. 2.19.)

**Ques. 2.71.** State the formula which is used in determining the reactance of an inductance.

*Ans.*

$$X_L = 2\pi f L,$$

where  $L$  is in henrys.

**Ques. 2.72.** What will be the inductive reactance of a 30-henry choke coil at 100 cycles?

*Ans.* The inductive reactance will be 18,840 ohms, computed as follows:

$$X_L = 2\pi fL$$
$$= 6.28 \times 100 \times 30 = 18,840 \text{ ohms.}$$

**Ques. 2.73.** What is the effect of an iron core in an inductance?

*Ans.* The effect is to increase the inductance value of the inductor.

**Ques. 2.74.** What will be the effect of a shorted turn in an inductance?

*Ans.* The effect of a shorted turn in an inductance will depend on circuit conditions. Theoretically, the first effect will be to reduce the value of the inductance. If the inductance is used in a high-frequency circuit, the shorted turn will change the distributed capacity of the coil and thereby change its  $L \times C$  value. If the shorted turn is in a coil carrying a sufficient amount of current, the shorted turn may heat up and burn out.

**Ques. 2.75.** What is the relationship between the number of turns and the inductance of a coil?

*Ans.* Inductance varies as the square of the number of turns, provided the length of the coil is the same.

**Ques. 2.76.** Define the term "reluctance."

*Ans.* "Reluctance" is the total opposition offered to the flow of magnetic lines of force in a magnetic circuit. The unit of reluctance is the oersted. The symbol for reluctance is the script letter  $\mathcal{R}$ .

**Ques. 2.77.** What are some of the factors which determine the "figure of merit" or  $Q$  of an inductance?

*Ans.* The following factors affect the  $Q$  of an inductance:

1. Frequency.
2. Inductance value.
3. Ohmic resistance.

4. Effective high-frequency resistance.
5. Method of winding.
6. Distributed capacity.
7. Dielectric losses in the coil form.
8. Permeability of the core.

The  $Q$  of an inductance is the ratio of the apparent inductive reactance of the coil to its effective resistance. The formula is  $Q = \frac{X}{R}$ .

**Ques. 2.78.** State the formula for determining the resonant frequency of a circuit when the inductance and capacitance are known.

*Ans.*

$$f = \frac{1}{2\pi\sqrt{LC}},$$

where  $L$  is in henrys.

$C$  is in farads.

**Ques. 2.79.** What is the formula for determining the power in a direct-current circuit when the voltage and resistance are known?

*Ans.*

$$P = I \times E = \frac{E}{R} \times E = \frac{E^2}{R}.$$

Hence,

$$P = \frac{E^2}{R} \text{ watts}$$

**Ques. 2.80.** What is the formula for determining the power in a direct-current circuit when the current and resistance are known?

*Ans.*

$$P = I^2R \text{ watts.}$$

**Ques. 2.81.** What is the formula for determining the power in a direct-current circuit when the current and voltage are known?

*Ans.*

$$P = EI \text{ watts.}$$

**Ques. 2.82.** What is the formula for determining the wavelength when the frequency, in kilocycles, is known?

*Ans.*

$$\lambda = \frac{3 \times 10^8}{f_1} = \frac{300,000}{f_2} \text{ meters}$$

where  $f_1$  = cycles,  $f_2$  = kilocycles.

**Ques. 2.83.** What is the frequency corresponding to a wavelength of 375 meters?

*Ans.* 800 kilocycles, computed according to the formula  $f = \frac{v}{\lambda}$ ; where  $v$  = velocity of radio wave,  $3 \times 10^8$  meters per second,  $\lambda$  equals wavelength in meters, and  $f$  = frequency in cycles per second.

**Ques. 2.84.** Define the term "apparent power."

*Ans.* The "apparent power" is the product of volts times amperes in any circuit. It includes the wattless component.

**Ques. 2.85.** State Ohm's law for alternating-current circuits.

*Ans.* Expressed mathematically Ohm's law adapted to alternating-current circuits reads:

$$E = IZ; \quad I = \frac{E}{Z}; \quad Z = \frac{E}{I}.$$

Stated in words these formulas show that the current  $I$  varies directly as the e.m.f.  $E$  and inversely as the impedance  $Z$ .

**Ques. 2.86.** Draw a simple schematic diagram showing a tuned-plate tuned-grid oscillator with series-fed plate. Indicate polarity of supply voltages.

**Ans.** See Fig. 2-2.

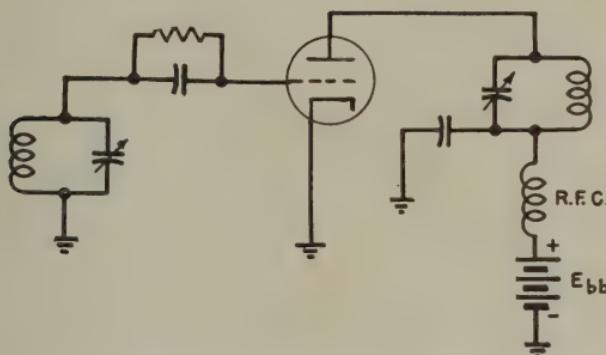
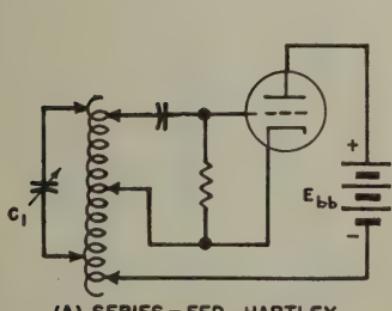


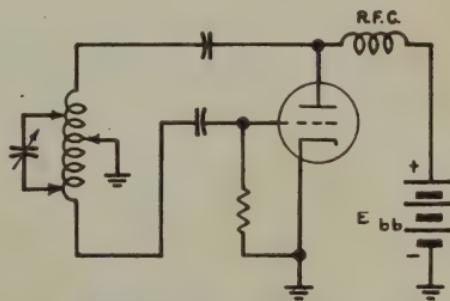
FIG. 2-2.—Tuned-plate tuned-grid series-fed oscillator.

**Ques. 2.87.** Draw a simple schematic diagram showing a Hartley triode oscillator with shunt-fed plate. Indicate power-supply polarity.

**Ans.** See Fig. 2-3 for both series and shunt circuits.



(A) SERIES-FED HARTLEY



(B) SHUNT-FED HARTLEY

FIG. 2-3.—Hartley oscillators.

Ques. 2.88. Draw a simple schematic diagram showing a tuned-grid Armstrong-type triode oscillator, with shunt-fed plate. Indicate power-supply polarity.

Ans. See Fig. 2-4.

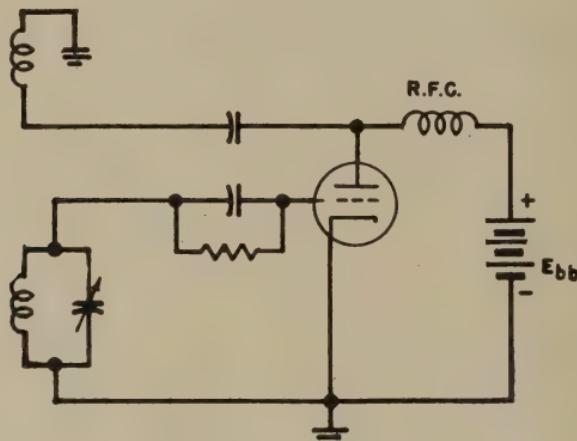


FIG. 2-4.—Armstrong tuned-grid shunt-fed oscillator.

Ques. 2.89. Draw a simple schematic diagram showing a tuned-plate tuned-grid triode oscillator with shunt-fed plate. Indicate polarity of supply voltages.

Ans. See Fig. 2-5.

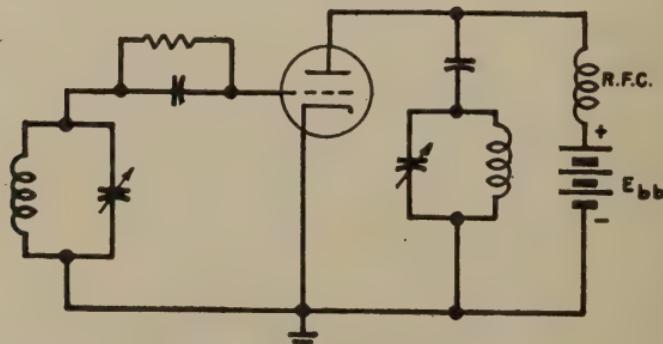


FIG. 2-5.—Tuned-plate tuned-grid shunt-fed oscillator.

**Ques. 2.90.** Draw a simple schematic diagram of a crystal-controlled vacuum-tube oscillator. Indicate power-supply polarity.

*Ans.* See Fig. 2-6.

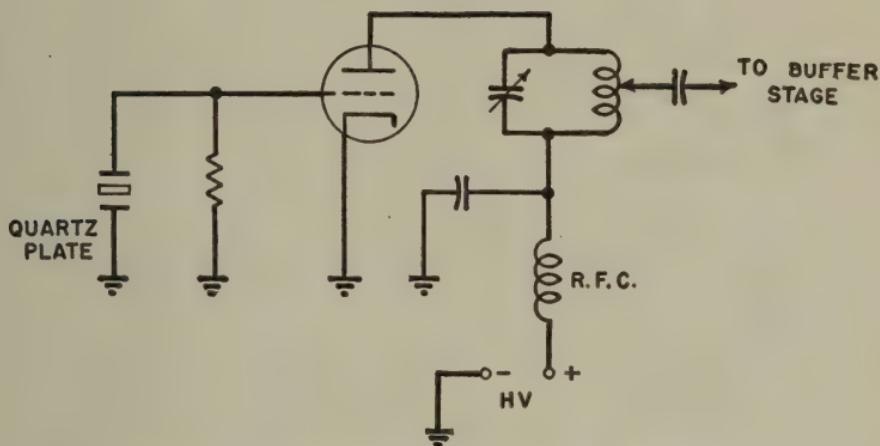


FIG. 2-6.—Triode-type crystal-controlled oscillator.

**Ques. 2.91.** Draw a simple schematic diagram showing a Colpitts-type triode oscillator, with shunt-fed plate. Indicate power-supply polarity.

*Ans.* See Fig. 2-7.

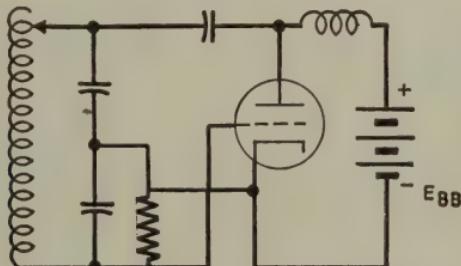


FIG. 2-7.—Colpitts shunt-fed oscillator.

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 2.92.** Draw a simple schematic diagram showing a tuned-grid Armstrong-type triode oscillator, with series-fed plate. Indicate power-supply polarity.

*Ans.* See Fig. 2-8.

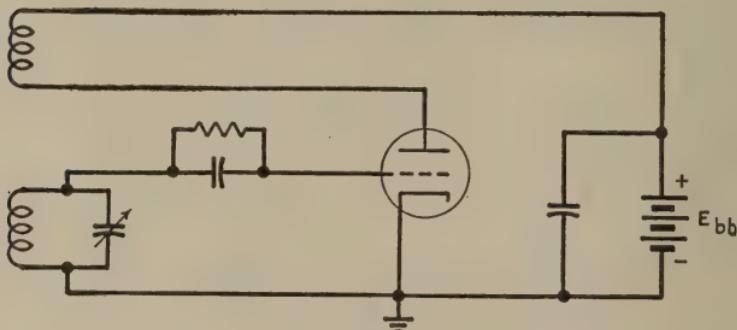


FIG. 2-8.—Armstrong series-fed oscillator.

**Ques. 2.93.** Draw a simple schematic diagram of an electron-coupled oscillator, indicating power-supply polarities.

*Ans.* See Fig. 2-9.

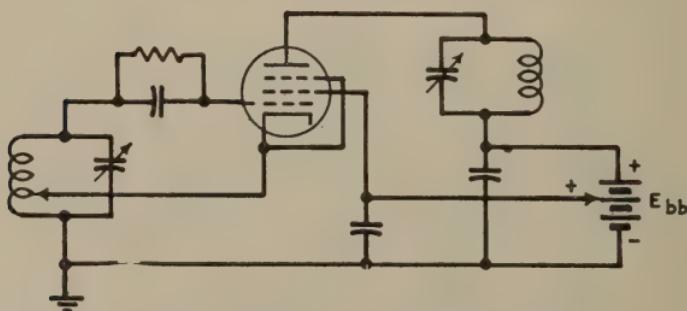


FIG. 2-9.—Electron-coupled oscillator.

**Ques. 2.94.** Draw a simple schematic diagram of a pentode-type tube used as a crystal-controlled oscillator, indicating power-supply polarities.

*Ans.* See Fig. 2-10.

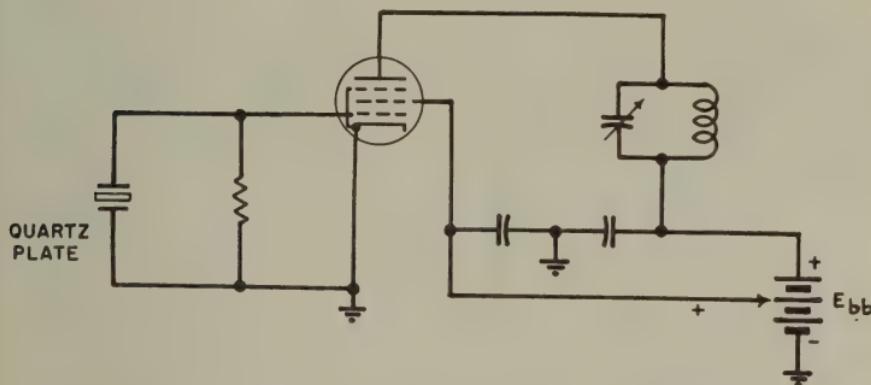


FIG. 2-10.—Pentode-type crystal-controlled oscillator.

**Ques. 2.95.** Draw a simple schematic circuit showing a method of coupling a high impedance loud-speaker to an audio-frequency amplifier tube without flow of tube-plate current through the speaker windings, and without the use of a transformer.

*Ans.* See Fig. 2-11.

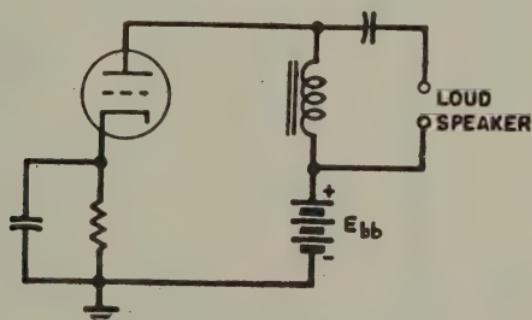


FIG. 2-11.—Loud-speaker coupling arrangement.

*RADIO OPERATING QUESTIONS AND ANSWERS*

**Ques. 2.96.** Draw a simple schematic diagram of a triode vacuum-tube audio-frequency amplifier inductively coupled to a loud-speaker.

**Ans.** See Fig. 2-12.

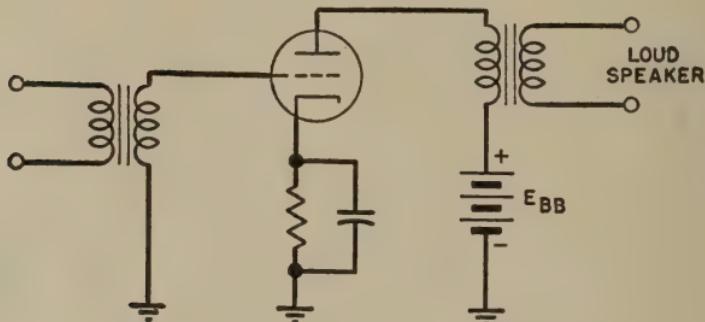


FIG. 2-12.—Loud-speaker coupling arrangement.

**Ques. 2.97.** Draw a simple schematic circuit showing a method of resistance coupling between two triode vacuum tubes in an audio-frequency amplifier.

**Ans.** See Fig. 2-13.

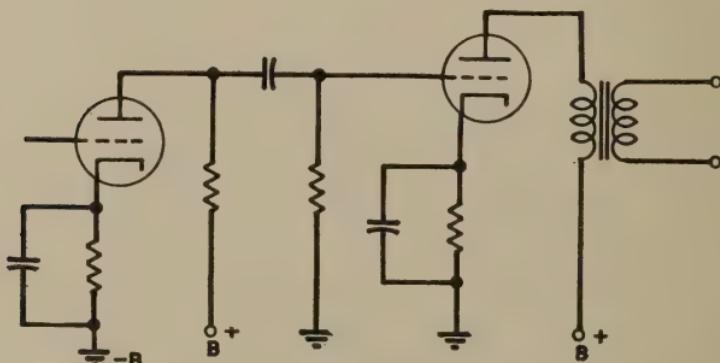


FIG. 2-13.—Resistance coupling.

**Ques. 2.98.** Draw a simple schematic diagram showing a method of transformer coupling between two triode vacuum tubes in an audio-frequency amplifier.

**Ans.** See Fig. 2-14.

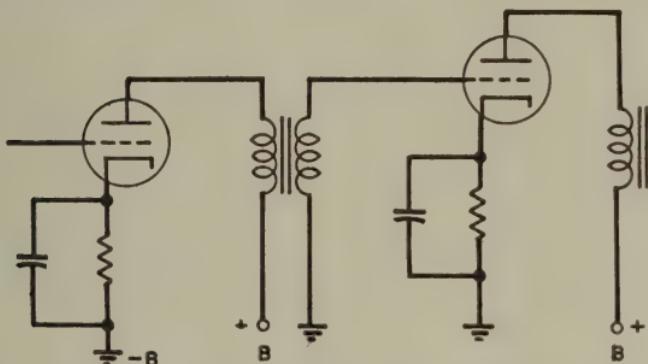


FIG. 2-14.—Inductive or transformer coupling.

**Ques. 2.99.** Draw a simple schematic diagram of a method of impedance coupling between two vacuum tubes in an audio-frequency amplifier.

**Ans.** See Fig. 2-15.

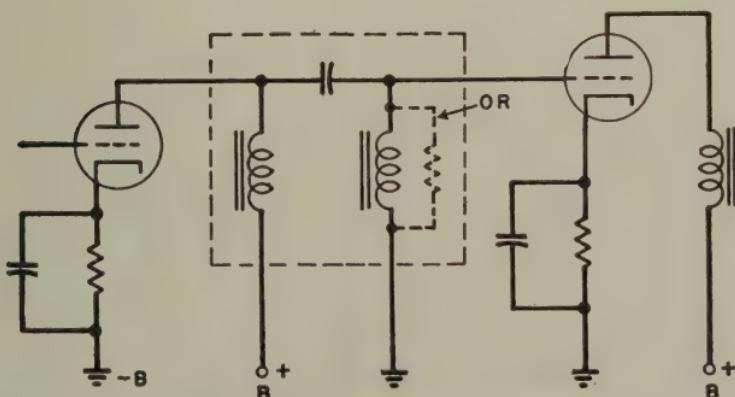


FIG. 2-15.—Impedance coupling.

*RADIO OPERATING QUESTIONS AND ANSWERS*

**Ques. 2.100.** Draw a diagram of a method of coupling a single radio-frequency amplifier using a triode tube to a push-pull radio-frequency amplifier using triode tubes, showing proper neutralization of the push-pull amplifier.

*Ans.* See Fig. 2-16.

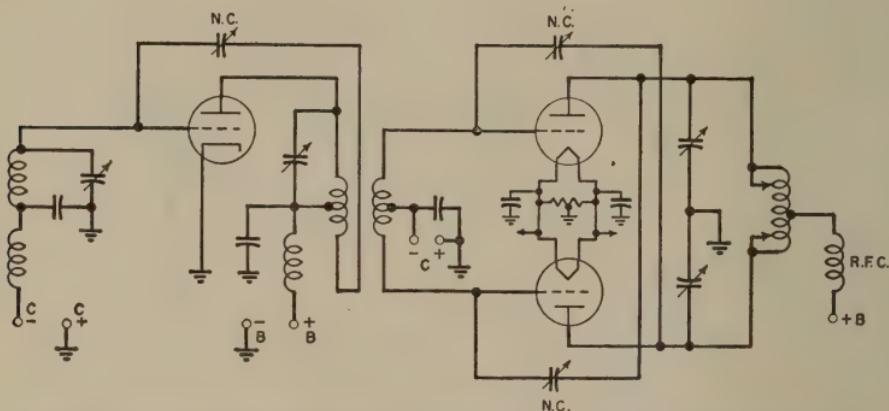


FIG. 2-16.—Radio-frequency amplifier with capacity neutralization.

**Ques. 2.101.** Draw a simple schematic circuit diagram of a radio-frequency amplifier, employing a triode electron tube and making use of plate neutralization.

*Ans.* See Fig. 2-17.

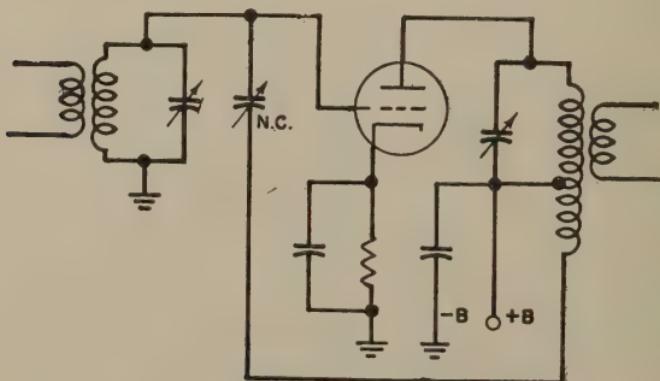


FIG. 2-17.—Plate neutralization system.

**Ques. 2.102.** Draw a simple schematic circuit diagram of a radio-frequency amplifier, employing a triode electron tube and making use of grid neutralization.

*Ans.* See Fig. 2-18.

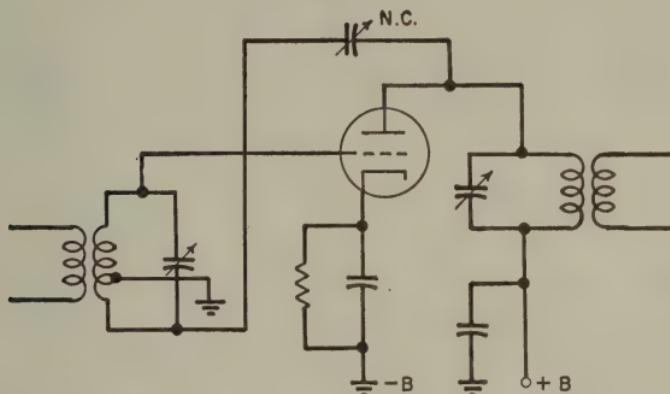
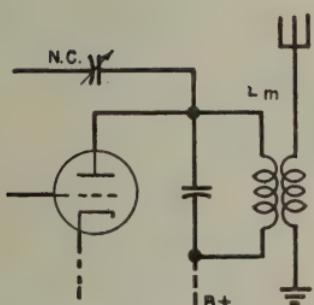


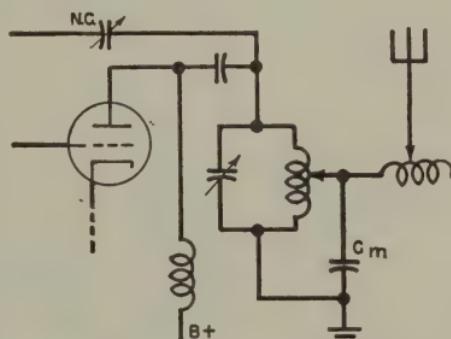
FIG. 2-18.—Grid neutralization system.

**Ques. 2.103.** Draw a simple schematic diagram showing a method of coupling the radio-frequency output of the final power-amplifier stage of a transmitter to an antenna.

*Ans.* See Fig. 2-19.



MAGNETIC COUPLING,  $L_m$



ELECTROSTATIC COUPLING,  $C_m$

FIG. 2-19.—Antenna coupling systems.

**Ques. 2.104.** Draw a simple schematic diagram showing a method of coupling between two tetrode vacuum tubes in a tuned radio-frequency amplifier.

*Ans.* See Fig. 2-20.

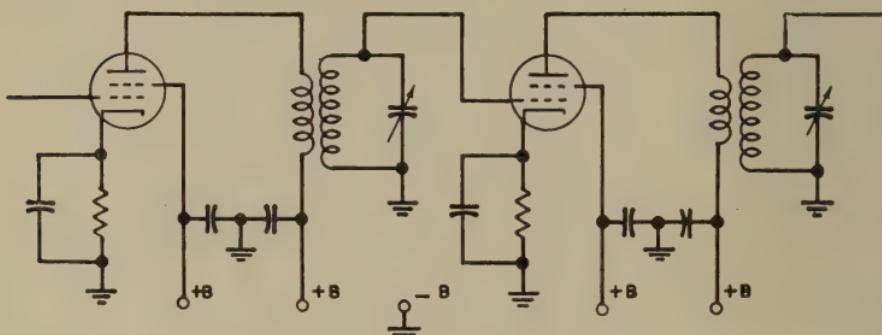


FIG. 2-20.—Interstage coupling system.

**Ques. 2.105.** Draw a simple schematic diagram showing a method of coupling between two triode vacuum tubes in a tuned radio-frequency amplifier, and a method of neutralizing to prevent oscillation.

*Ans.* See Fig. 2-21.

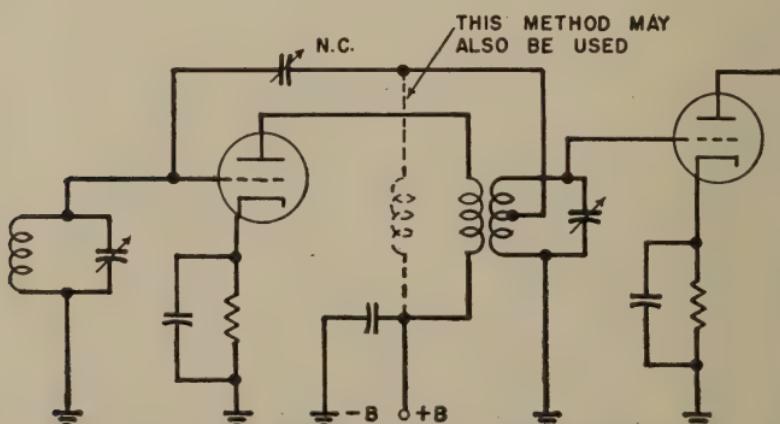


FIG. 2-21.—Interstage coupling and neutralization.

**Ques. 2.106.** Draw a simple schematic diagram of a diode vacuum tube connected for diode detection, and showing a method of coupling to an audio amplifier.

*Ans.* See Fig. 2-22.

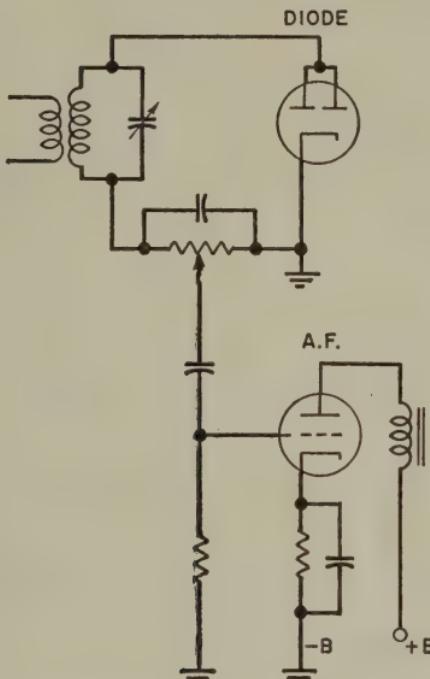


FIG. 2-22.—Diode detector and audio-frequency amplifier.

**Ques. 2.107.** Draw a simple schematic diagram of a triode vacuum tube connected for plate or power detection.

*Ans.* See Fig. 2-23.

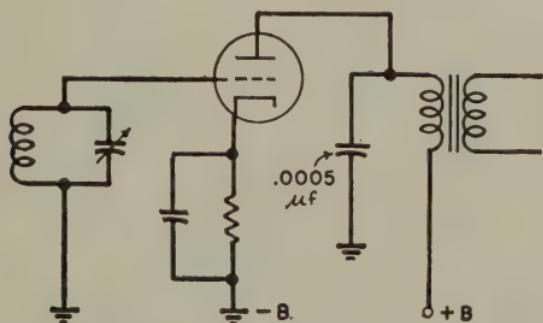


FIG. 2-23.—Power or plate detection system.

RADIO OPERATING QUESTIONS AND ANSWERS

Ques. 2.108. Draw a simple schematic diagram of a triode tube connected for grid-leak condenser detection.

Ans. See Fig. 2-24.

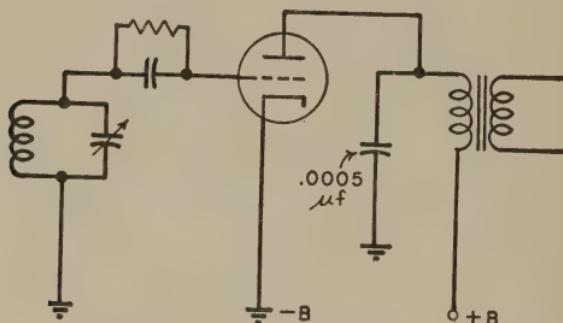


FIG. 2-24.—Grid-leak detector.

Ques. 2.109. Draw a simple schematic circuit of a regenerative detector.

Ans. See Fig. 2-25.

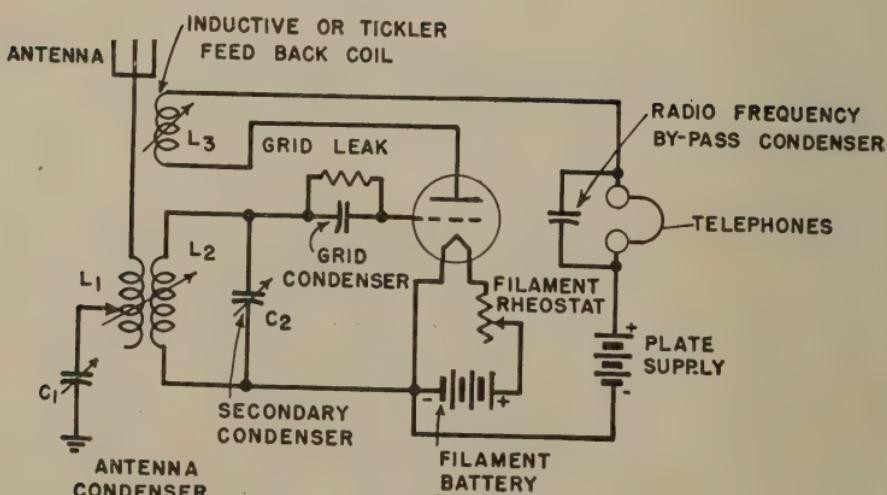


FIG. 2-25.—Regenerative detector.

**Ques. 2.110.** Draw a simple schematic circuit of a radio-frequency doubler stage, indicating any pertinent points which will distinguish this circuit as that of a frequency doubler.

**Ans.** See Fig. 2-26. (Draw first doubler stage only to answer this question.) Doubler is biased to class C operation and plate tank tuned to double the input frequency to the grid circuit.

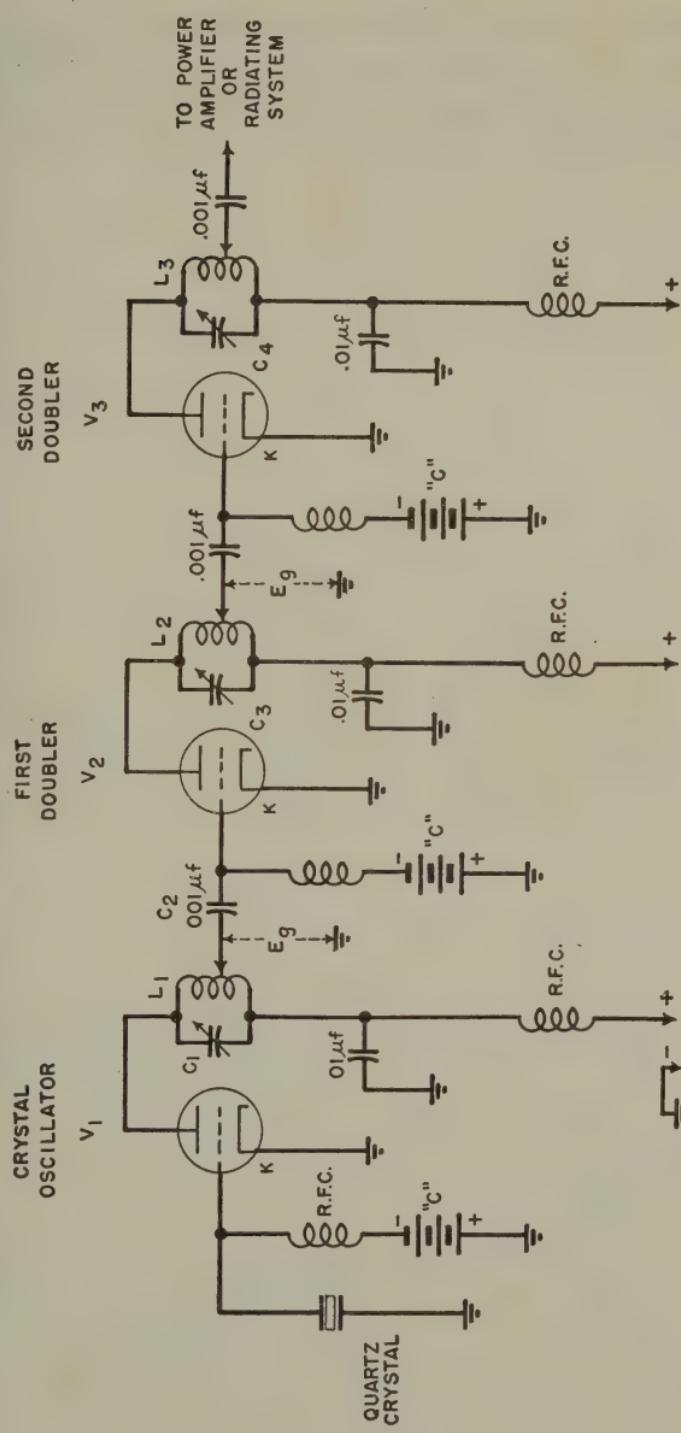


FIG. 2-26.—Radio-frequency doubling system.

*RADIO OPERATING QUESTIONS AND ANSWERS*

**Ques. 2.111.** Draw a simple schematic diagram showing the method of connecting three resistors of equal value so that the total resistance will be two-thirds the resistance of one unit.

*Ans.* See Fig. 2-27.

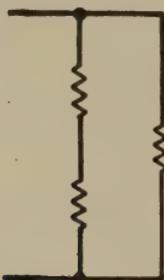


FIG. 2-27.—Parallel resistance combination.

**Ques. 2.112.** Draw a simple schematic diagram showing the method of connecting three resistors of equal value so that the total resistance will be  $1\frac{1}{2}$  times the resistance of one unit.

*Ans.* See Fig. 2-28.

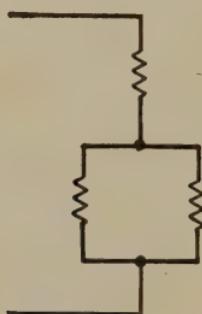


FIG. 2-28.—Series-parallel resistance combination.

**Ques. 2.113.** Draw a simple schematic diagram to indicate how a 60-cell bank of lead-acid storage batteries may be connected to permit charging in parallel from a 110-volt direct-current source and discharging in series, including necessary switches.

*Ans.* See Fig. 2-29.

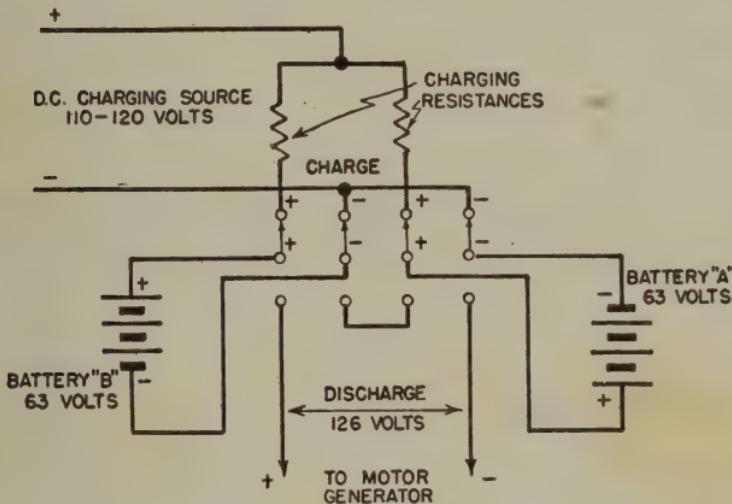


FIG. 2-29.—Battery charging arrangement.

**Ques. 2.114.** Draw a diagram of a simple shunt rejector or wave-trap circuit, in series with a receiving antenna circuit, designed to suppress an undesired signal.

*Ans.* See Fig. 2-30.

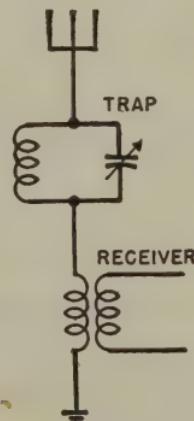


FIG. 2-30.—  
Shunt-rejector  
wave trap.

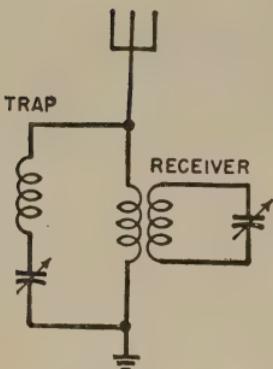


FIG. 2-31.—Series wave trap.

Ques. 2.115. Draw a diagram of a simple series wave-trap circuit, connected in shunt with the input terminals of a radio receiver, and designed to bypass an undesired signal.

Ans. See Fig. 2-31.

Ques. 2.116. Draw a simple schematic diagram of an underload circuit breaker as used with battery charging circuits.

Ans. See Fig. 2-32.

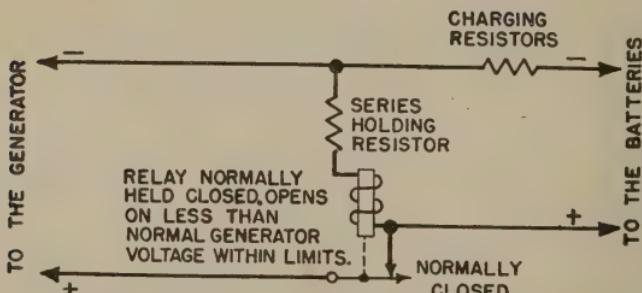


FIG. 2-32.—Underload circuit breaker.

Ques. 2.117. Draw a simple schematic diagram showing the method of connecting three resistors of equal value so that the total resistance will be one-third of one unit.

Ans. See Fig. 2-33.

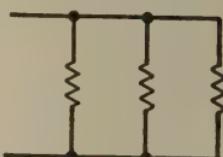


FIG. 2-33.—Parallel resistance combination.

**Ques. 2.118.** Draw a simple schematic diagram of a shunt-wound self-excited, direct-current motor, with provision for starting and regulating speed, including indication of direct-current source.

*Ans.* See Fig. 2-34.

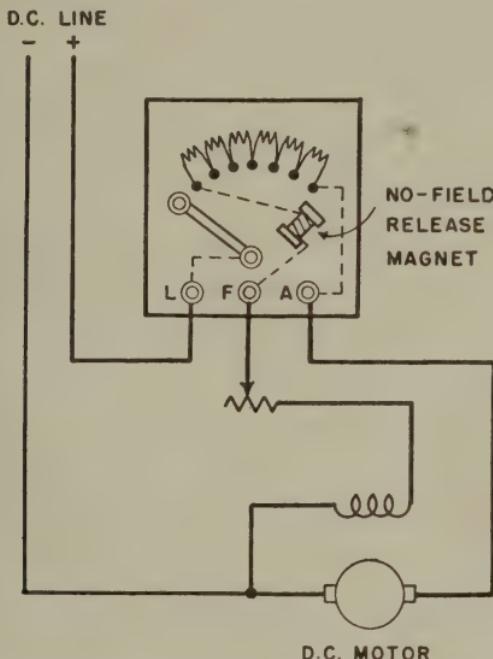


FIG. 2-34.—Shunt-wound motor, speed regulator, and starter.

**Ques. 2.119.** Draw a simple schematic diagram showing the method of connecting three resistors of equal value so that the total resistance will be three times the resistance of one unit.

*Ans.* See Fig. 2-35.

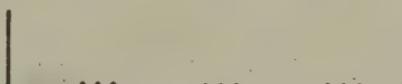


FIG. 2-35.—Series resistance combination.

**Ques. 2.120.** Draw a diagram of a single-button carbon-microphone circuit, including the microphone transformer and source of power.

*Ans.* See Fig. 2-36.

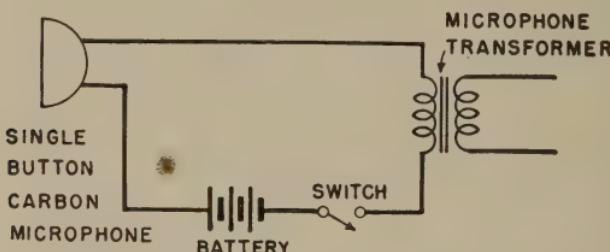


FIG. 2-36.—Carbon-microphone circuit arrangement.

**Ques. 2.121.** What is meant by a "soft" vacuum tube?

*Ans.* A tube containing a small amount of gas which was not excluded during the manufacturing process.

**Ques. 2.122.** What is meant by a "thyatron"?

*Ans.* The "thyatron" is a filamentary-type hot-cathode gas-filled tube. The filament may be a nickel ribbon wound in the form of a helix and coated with an alkaline earth carbonate. A carbonized nickel grid is mounted so that it intercepts the electron stream produced by the filament. A carbonized nickel anode is mounted opposite the filament on the other side of the grid. The thyatron functions as a high-voltage rectifier tube. Thyatrons are also made as four-element tubes, having a so-called shield grid as the fourth element.

Because the thyatron is fitted with a control grid, the large rectified voltages flowing in the tube can be controlled by a small control voltage, the tube thus acting as a power control device.

**Ques. 2.123.** Describe the physical structures of the tetrode and pentode on a comparative basis.

*Ans.* The tetrode has four elements, namely, (1) cathode, (2) control grid, (3) screen grid, (4) plate.

The pentode has five elements, including all of those just mentioned for the tetrode, and, in addition, a fifth element called the suppressor grid. The suppressor grid is generally (but not always) connected directly to the cathode. Therefore, it assumes a negative potential with respect to the plate, and retards secondary emission.

**Ques. 2.124.** Describe the electrical characteristics of the pentode, tetrode, and triode on a comparative basis.

*Ans.* The pentode is a five-element tube, the distinctive feature of which is a suppressor grid usually directly connected to the cathode and serving to prevent secondary emission. When the pentode is used as a power-output amplifier, the suppressor makes possible a large power output with high gain, because the plate swing can be made very large. When the pentode is used as a radio-frequency amplifier, high-voltage amplification is possible using moderate values of plate voltage. Because the pentode also has a screen grid, interelement capacitance is minimized and an external system of neutralization is generally unnecessary when the tube is used as a radio-frequency amplifier.

The tetrode is a four-element tube, the distinctive feature of which is a screen grid located between the control grid and the plate. The screen grid serves to neutralize or reduce the grid-to-plate capacitance, thus making the tube suitable for use in most types of radio-frequency amplifier circuits without the application of special neutralizing methods.

The screen grid is operated at a positive voltage lower than that of the plate. A desirable result achieved is that the screen grid makes plate current practically independent of plate voltage within limits. Because the screen grid is charged with a positive potential, it serves as an extra force for pulling electrons through the space charge. Because the plate current in the tetrode is independent of the plate voltage, a much higher gain per stage is possible with a tetrode than with a triode, other conditions being equal.

## *RADIO OPERATING QUESTIONS AND ANSWERS*

The triode is a three-element tube, consisting of cathode, grid, and plate. The purpose of the grid is to control the flow of electrons from the filament to the plate. When the tube is used as an amplifier, the grid is usually operated with a negative bias. A negative charge on the grid tends to reduce plate current; while a positive charge on the grid tends to increase plate current. Therefore, when an alternating signal voltage is applied to the grid, the plate current varies in accordance with the applied signal voltage. Because there is electrostatic capacity between the grid and the plate, allowing a feedback of radio-frequency energy between these elements, it is necessary to compensate this interelement capacitance by an external system of neutralization.

**Ques. 2.125. What are the visible indications of a "soft" tube?**

*Ans.* Visible indications of a "soft" tube are that the tube usually shows a blue haze between the filament and the plate, and the plate may become excessively reddened. These visible indications would be accompanied by very erratic operation and a heavy increase in plate current. Ordinarily a "soft" tube will show up by an excessive plate-current reading.

**Ques. 2.126. Describe the physical structure of a triode vacuum tube.**

*Ans.* A triode is a three-element vacuum tube, containing a filament, or cathode, a control grid usually surrounding the filament, and a plate. The control grid, as its name implies, controls the flow of electrons from the filament to the plate. All of the elements are mounted in a glass bulb with a base through which connections are made to the elements. In high-voltage tubes, the connections to some of the elements may be taken through the side or top of the glass envelope.

**Ques. 2.127. Describe the physical structure of a tetrode vacuum tube.**

*Ans.* A tetrode is a four-element vacuum tube, containing a filament, or cathode, a control grid usually surrounding the filament, a screen grid usually surrounding the control grid, and a plate. The control grid, as in the triode, controls the flow of electrons from the filament to the plate. All of the elements are mounted in a glass bulb with a base through which connection is made, generally to all of the elements, except the control grid, which is brought out to a metal cap at the top of the glass envelope. In high-voltage tubes, the connections to the control grid and the plate may be taken through the side or the top of the glass envelope.

**Ques. 2.128.** Does a pentode vacuum tube usually require neutralization when used as a radio-frequency amplifier?

*Ans.* Not ordinarily. However, in some ultra-high-frequency circuits, where the pentode is used as a radio-frequency amplifier, neutralization may be necessary.

**Ques. 2.129.** What is the meaning of "plate impedance"?

*Ans.* Because an alternating component flows in the plate circuit, the capacitance of the plate with respect to the filament must sometimes be considered. In addition to this capacitance, there is the effective internal plate-to-filament resistance of the tube. Taken together, these two factors constitute the internal plate impedance of the tube. As the capacitive reactance of the tube need be considered only when the ultra-high frequencies are involved, it is generally sufficient to consider the plate impedance of the tube to be equal to the effective internal plate-to-filament resistance of the tube.

**Ques. 2.130.** What is the meaning of "mutual conductance"? "Transconductance"?

*Ans.* "Mutual conductance" ( $G_m$ ), also known as "transconductance" ( $S_g$ ), is a figure of merit for comparing vacuum tubes. It combines in one term the amplification factor and

## RADIO OPERATING QUESTIONS AND ANSWERS

the plate resistance of the tube and is the ratio of the first to the second. The formula is:

$$G_m = \mu/Rp.$$

“Mutual conductance” or “transconductance” may also be defined as the ratio of a small change in the plate current to the change in grid voltage necessary to produce the same change in the plate current under a constant plate voltage.

**Ques. 2.131.** What is the meaning of “secondary emission”?

*Ans.* When primary electrons from the filament are drawn to the plate of a vacuum tube with such force that they, in turn, dislodge electrons from the surface of the plate by their impact force, the electrons so dislodged are called “secondary electrons.” The emission of these electrons from the plate is called “secondary emission” to differentiate it from the primary emission from the filament. Secondary emission opposes and reduces the normal plate-current flow.

**Ques. 2.132.** What is the meaning of “amplification factor”?

*Ans.* “Amplification factor” ( $\mu$ ) denotes the amount of amplification possible in a tube. It is the ratio of the change in plate voltage to a change in control electrode voltage in the opposite direction, under the condition that the plate current remains unchanged. The formula for amplification factor is

$$\mu = dE_p/dE_g$$

**Ques. 2.133.** What is the meaning of “electron emission”?

*Ans.* “Electron emission” is the liberation of electrons from a material when it is heated to a point at which electrons break through the surface tension of the material.

**Ques. 2.134.** Describe the characteristics of a vacuum tube operating as a class C amplifier.

*Ans.* This type of amplifier is very efficient because plate current flows only during intervals when the plate resistance of the tube is low. Hence, the tube runs cool and its efficiency is high. The class C amplifier is biased to a point which is appreciably greater than the cut-off value. The bias may be from  $1\frac{1}{2}$  to 4 times the cut-off value, depending upon circuit conditions.

In a class C amplifier, the plate output power varies as the square of the plate voltage within limits and is high.

**Ques. 2.135.** During what portion of the excitation voltage cycle does plate current flow when a tube is used as a class C amplifier?

*Ans.* Plate current flows in a class C amplifier for a period which is appreciably less than one-half of each excitation cycle when an alternating voltage is applied to the grid.

**Ques. 2.136.** Describe the characteristics of a vacuum tube operating as a class A amplifier.

*Ans.* The characteristics of a class A amplifier are that the output wave shape is essentially a linear reproduction of the grid voltage. The ratio of voltage amplification is high, but the efficiency of the tube as an amplifier is low. Plate current flows during the entire excitation cycle.

**Ques. 2.137.** Describe the characteristics of a vacuum tube operating as a class B amplifier.

*Ans.* The output power of a class B amplifier is proportional to the square of the excitation voltage. The ratio of power amplification is low. The efficiency is medium.

**Ques. 2.138.** During what portion of the excitation voltage cycle does plate current flow when a tube is used as a class B amplifier?

## RADIO OPERATING QUESTIONS AND ANSWERS

*Ans.* Plate current flows in a class B amplifier for approximately one-half of each excitation cycle when an alternating voltage is applied to the grid.

**Ques. 2.139.** Does a properly operated class A audio amplifier produce serious modification of the input wave form?

*Ans.* No; its operation is essentially linear.

**Ques. 2.140.** What is the meaning of the term "maximum plate dissipation"?

*Ans.* The maximum power, caused as a direct result of electric bombardment of the plate, which can be dissipated by the plate as heat, is known as the "maximum plate dissipation."

Plate dissipation =  $E_p \times I_p$ , where the voltage and current values are measured directly on the plate.

**Ques. 2.141.** What is meant by a "blocked grid"?

*Ans.* A tube has a "blocked grid" when the grid bias is of such a value as to shut off plate current.

**Ques. 2.142.** What is meant by the "load" on a vacuum tube?

*Ans.* The resistance or impedance into which the output of the tube is fed.

**Ques. 2.143.** What circuit and electron-tube factors influence the voltage gain of a triode audio-frequency amplifier stage?

*Ans.* The following factors affect the voltage gain of a triode audio-frequency amplifier stage: amplification factor of the tube; turns ratio of the coupling transformer, if used; plate potential; excitation voltage; load impedance.

**Ques. 2.144.** What is the purpose of a bias voltage on the grid of an audio-frequency amplifier tube?

*Ans.* The purpose of the bias voltage is to place the operating point at the desired location on the  $I_p$ - $E_g$  characteristic. The grid bias also prevents grid-current flow in class A amplifier operation and allows high excitation without too much grid-current flow in class B operation.

**Ques. 2.145.** What is the primary purpose of a screen grid in a vacuum tube?

*Ans.* To reduce to an ordinarily negligible quantity the capacitance between the grid and the plate, making neutralization unnecessary because of the absence of feedback. This might not be true in ultra-high-frequency circuits in which neutralization of the screen grid tube might sometimes be necessary.

**Ques. 2.146.** What is the primary purpose of a suppressor grid in a multi-element vacuum tube?

*Ans.* To retard the emission of secondary electrons from the plate, which, otherwise, would flow to the screen grid, reducing plate current and limiting permissible plate swing.

**Ques. 2.147.** What is the meaning of the term "plate saturation"?

*Ans.* "Plate saturation" is the condition present when practically all of the electrons which are emitted from the filament of the tube reach the plate for the filament voltage applied.

**Ques. 2.148.** What is the most desirable factor in the choice of a vacuum tube to be used as a voltage amplifier?

*Ans.* The most desirable factor in a voltage amplifier tube is a high mutual conductance ( $gm$ ).

**Ques. 2.149.** What is the principal advantage of a tetrode over a triode as a radio-frequency amplifier?

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ans.** The principal advantage of the tetrode over the triode in radio-frequency amplification is that when the tetrode is used neutralization is unnecessary, except, perhaps, in some ultra-high-frequency circuits.

**Ques. 2.150.** What is the principal advantage of the tetrode as compared to the triode, when used in a radio receiver?

**Ans.** The tetrode eliminates the necessity for neutralizing the radio-frequency stages. Hence, radio-frequency amplification becomes practical.

**Ques. 2.151.** What is the principal advantage in the use of a diode detector instead of a grid-leak type triode detector?

**Ans.** The diode detector will give less distortion, particularly on strong or high percentage modulated signals.

**Ques. 2.152.** Draw a grid voltage-plate current characteristic curve of a vacuum tube and indicate the operating points for class A, class B, and class C amplifier operation.

**Ans.** See Fig. 2-37.

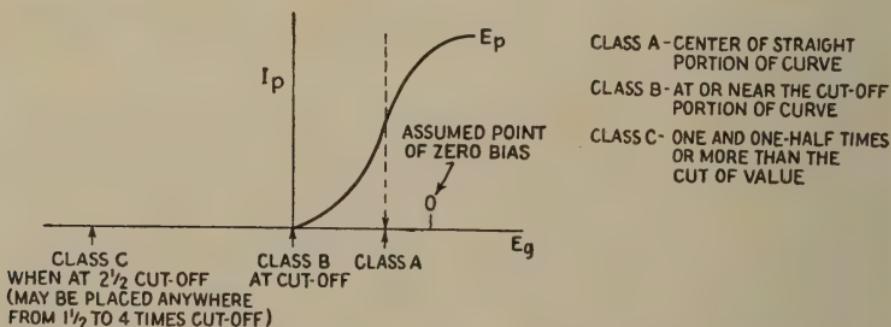


FIG. 2-37.—Vacuum-tube operating-curve adjustments for class A, class B, and class C amplification.

**Ques. 2.153.** What operating conditions determine that a tube is being used as a power detector?

*Ans.* The tube is operated near the cut-off point on the  $E_g$ - $I_p$  curve. Bias voltage can be obtained from a cathode resistor, a C battery, or a bleeder tap on the power supply.

**Ques. 2.154.** Why is it desirable to use an alternating-current filament supply for vacuum tubes?

*Ans.* The use of alternating current on the filaments of vacuum tubes eliminates the necessity for cumbersome filament batteries and charging apparatus or rectifier units and filters for supplying direct current from an alternating-current line. In general, the entire operation of the system is simplified because filament power can be taken directly from the alternating-current line through a step-down transformer.

**Ques. 2.155.** Why is it advisable periodically to reverse the polarity of the filament potential of high-power vacuum tubes when a direct-current filament supply is used?

*Ans.* It is advisable periodically to reverse the polarity of the filament potential in order to lengthen the life of the filament. The electronic emission is not uniform over the entire length of the filament since the variable space current present all along the filament causes a difference in the temperature of the filament at various points along its length. Hence, the resistance of the filament is altered with a consequent change in the filament's potential gradient. All of these effects taken together, if allowed to operate without variation on a filament, will tend to shorten its life. By reversing the filament potential at regular intervals, this strain is periodically redistributed on the filament and its life lengthened.

**Ques. 2.156.** Why is it important to maintain transmitting-tube filaments at recommended voltages?

*Ans.* If the filament voltage is *above* normal, the life of the tube is shortened. If the filament voltage is *below* normal, the tube will not give optimum results because of a deficiency in

## RADIO OPERATING QUESTIONS AND ANSWERS

its electron-emitting qualities. Hence, it is important to keep the filament voltage at the rated value.

**Ques. 2.157.** How may certain vacuum-tube filaments be reactivated?

*Ans.* Filaments of thoriated tungsten are the only type which can be reactivated. The procedure is to disconnect all voltages from the grids and plate of the tube and apply a filament voltage of about  $2\frac{1}{2}$  times normal for 20 seconds; then reduce the filament voltage to about 20 per cent more than normal and allow the filament to burn with this voltage for about 30 minutes.

**Ques. 2.158.** When an alternating-current filament supply is used, why is a filament center tap usually provided for the vacuum-tube plate and grid return circuits?

*Ans.* If the filament return circuits were connected to one side of the filament, the bias on the grid would be varied by an amount equal to the filament voltage at each reversal of filament polarity. This action would cause audio-frequency modulation in the tube and a hum in the circuit.

**Ques. 2.159.** What type of vacuum-tube filaments may be reactivated?

*Ans.* Thoriated tungsten filaments are the only type of filament which may be reactivated. These filaments are usually found only in transmitting tubes of medium power ratings.

**Ques. 2.160.** Explain the operation of a grid-leak type of detector.

*Ans.* In the grid-leak type of detector, the grid is isolated from the rest of the tube circuit by a blocking condenser. Hence, on each positive alternation of the signal voltage the grid is left with a gradually increasing excess of electrons. When the grid has accumulated a peak charge of electrons,

they leak off through the grid-leak resistance. The gradual build-up and leak-off cause a corresponding decrease in plate current which, therefore, conforms to the envelope of the audio component of the modulated signal wave. This audio component can be used as is or amplified further to actuate a telephone receiver or loud-speaker.

**Ques. 2.161.** List and explain the characteristics of a square-law type of vacuum-tube detector.

*Ans.* The grid-leak-and-condenser type detector is a square-law detector, the output wave shape varying as the square of the signal input voltage. This results in a detector which is very sensitive, but has a high percentage of harmonic distortion. The square-law detector responds only to a modulated signal input on its grid circuit. Hence, the square-law detector cannot respond to continuous-wave (type A1) emission applied to its grid circuit.

**Ques. 2.162.** Explain the operation of a diode type of detector.

*Ans.* In the diode detector the plate of the tube conducts plate current only during the positive alternation of the signal voltage cycle. These pulses of plate current vary to produce an audio component which is proportional to the modulated signal voltage impressed on the tube. The diode, therefore, operates as a simple rectifier.

**Ques. 2.163.** Explain the operation of a power or plate rectification type of vacuum-tube detector.

*Ans.* In power or plate rectification the grid is biased almost to the cutoff point. Hence, plate current flows only during the positive alternation of the signal voltage impressed on the grid, causing a consequent rise in plate current. The output wave shape conforms to that of the signal voltage.

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 2.164.** Is a grid-leak type of detector more or less sensitive than a power detector (plate rectification)? Why?

*Ans.* The grid-leak type of detector is the more sensitive because it operates at zero bias at which point the mutual conductance is *maximum*. The plate detector operates near cut-off at which point the mutual conductance is *minimum*.

**Ques. 2.165.** Describe what is meant by a class A amplifier.

*Ans.* A class A amplifier operates in such a manner that the plate-output wave form is essentially the same as the excitation grid voltage. Plate current flows during the entire excitation cycle. The grid must usually not go positive on excitation peaks, and the plate current must not fall low enough at its minimum to cause distortion. (Adapted from I.R.E. definitions.)

**Ques. 2.166.** What are the characteristics of a Class A audio amplifier?

*Ans.* A relatively high voltage gain, low efficiency with a linear output, and a constant direct-current plate current component, are the identifying characteristics of a class A amplifier.

**Ques. 2.167.** What are the advantages of operating two tubes in push-pull rather than in parallel for an audio-frequency amplifier?

*Ans.* If two *matched* tubes are operated in push-pull, the nonlinearities of their characteristics compensate each other to the extent that a symmetrical output wave form is secured. No even harmonics are produced in this stage.

**Ques. 2.168.** What will be the effect of incorrect grid bias in a class A audio amplifier?

*Ans.* An incorrect grid bias may cause nonsymmetry with consequent distortion of the output wave form.

**Ques. 2.169.** Why is an audio transformer seldom used in the plate circuit of a tetrode used as an audio-frequency amplifier?

*Ans.* The plate impedance of a tetrode voltage-amplifier tube is generally between 250,000 and 1,000,000 ohms. Since it is common practice in class A amplifiers to have a load impedance of twice the plate resistance to effect a true reproduction of the signal wave shape, the tetrode would require a transformer of enormous inductance value to give the required impedance. It is for this reason that resistance coupling is used whenever very high-impedance tubes are used in audio-frequency amplifier systems.

**Ques. 2.170.** What are the factors which determine the bias voltage for the grid of a vacuum tube?

*Ans.* The efficiency to be achieved, the class of amplifier operation, the excitation voltage available, the plate potential to be used, the permissible swing of the alternating-current component, and the second-harmonic content allowed are all factors which affect the final selection of bias voltage for the grid of a vacuum tube.

**Ques. 2.171.** Why are tubes, operated as class C amplifiers, not suited for audio-frequency amplification?

*Ans.* Because there is too much distortion present in the output of the class C amplifier to make it feasible for use on audio frequencies. Hence, class C amplifiers are used primarily in the amplification of the unmodulated radio-frequency carrier wave in radio transmitters.

**Ques. 2.172.** Draw a circuit of a frequency doubler and explain its operation.

*Ans.* See Fig. 2-26 for diagram. The tube is biased beyond the cutoff point. This produces a distorted plate-current wave shape which contains a large percentage of harmonics. The

## RADIO OPERATING QUESTIONS AND ANSWERS

plate  $L-C$  circuit is tuned to twice the input frequency (second harmonic). Hence, this frequency is amplified.

**Ques. 2.173.** For what purpose is a doubler amplifier stage used?

*Ans.* The doubler amplifier is used when an output frequency greater than the maximum safe operating frequency of a crystal oscillator is desired.

**Ques. 2.174.** How would the loss of radio-frequency excitation affect a class C modulated amplifier using grid-leak bias only?

*Ans.* The result of loss of excitation in a class C modulated amplifier, or any amplifier using grid-leak bias only, would be an excessive rise in plate current with probable ruination of the tube if safety devices were not provided in the circuit. The reason is that the bias which keeps the plate current down to safe limits is produced by the grid-current flow in the grid leak. When excitation is removed, no grid current flows, and, therefore, the bias is removed with the consequent damaging results.

**Ques. 2.175.** What effect upon the vacuum-tube plate current will be noted as the plate circuit resonant frequency of radio-frequency amplifier is varied?

*Ans.* The plate current will be minimum at the resonant point and will rise sharply to maximum on both sides of the resonant adjustment.

**Ques. 2.176.** What type of oscillator or amplifier is best suited for use in a frequency meter? Describe the desirable characteristics.

*Ans.* The electron-coupled oscillator is best suited for use in a frequency meter. Desirable characteristics of an oscillator used in a frequency meter are as follows:

1. Voltage compensation of plate and screen voltages to minimize frequency variations.
2. Minimum frequency deviation when apparatus under measurement is coupled directly to the meter.
3. Visual resonance indicator.
4. Battery operated.
5. Portable.

**Ques. 2.177.** Describe what is meant by "link coupling" and for what purpose(s) is it used?

*Ans.* "Link coupling" is the term applied to the coupling provided between two major circuits by an intermediate link circuit, which may, in turn, be defined as two inductors joined by a relatively short transmission line and inductively coupled to the major circuits.

**Ques. 2.178.** What factors may cause low plate current in a vacuum-tube amplifier?

*Ans.* The following factors may cause low plate current:

1. Deactivated tube.
2. Excessive grid bias.
3. Defective filter condenser.
4. Low operating voltages.
5. Improper coupling to excitation circuit.

If a crystal filter is used, low plate current may be caused by a dirty crystal.

**Ques. 2.179.** Given the following electron-tube constants  $Ep = 1,000$  volts,  $Ip = 150$  milliamperes,  $Ig = 10$  milliamperes, and grid leak = 5,000 ohms, what would be the value of direct-current grid-bias voltage?

*Ans.* The value of grid-bias voltage would be 50 volts because a current of 10 milliamperes flows through a grid-leak resistor of 5,000 ohms. This, according to Ohm's law, would yield a voltage drop of 50 volts.

**Ques. 2.180.** Explain how you would determine the value of cathode-bias resistance necessary to provide correct grid bias for any particular amplifier.

*Ans.* The correct value of cathode-bias resistance necessary to provide correct grid bias for any particular amplifier can easily be found by Ohm's law if the current flow through the resistor is known. This current will consist of the sum of the plate and grid currents, which are combined to form the  $I$  factor in the formula  $R = \frac{E}{I}$ , where  $E$  equals the desired bias voltage.

**Ques. 2.181.** Under what load conditions will a vacuum tube have the highest ratio of power output to plate-circuit direct-current input?

*Ans.* This ratio equals the plate efficiency. Plate efficiency is maximum under unity power factor conditions. Depending on the  $Q$  of the tank circuit, unity power factor conditions with a coupled circuit may or may not be at the point of maximum impedance for the uncoupled circuit. However, in a well-designed transmitter, where the  $Q$  of the circuits is high, the unity power factor adjustment and the adjustment for minimum plate current, maximum impedance condition, is the same.

**Ques. 2.182.** Under what load conditions will a vacuum tube produce its greatest output?

*Ans.* When the plate load resistance or impedance equals the plate resistance of the tube.

**Ques. 2.183.** What is the chemical composition of the active material composing the negative plate of a lead-acid type storage cell?

*Ans.* Pure sponge lead, Pb.

**Ques. 2.184.** What is the chemical composition of the active material composing the negative plate of an Edison-type storage cell?

*Ans.* Iron oxide.

**Ques. 2.185.** What is the chemical composition of the active material composing the positive plate of a lead-acid type storage cell?

*Ans.* Lead dioxide,  $\text{PbO}_2$ .

**Ques. 2.186.** How does a primary cell differ from a secondary cell?

*Ans.* A secondary cell can be recharged; a primary cell cannot be recharged. As used in radio the secondary cell is either the familiar lead-type or the Edison storage battery; the primary cell is a dry cell.

**Ques. 2.187.** What is the chemical composition of the active material composing the positive plate of an Edison-type storage cell?

*Ans.* Nickel hydroxide and exceedingly thin flakes of pure nickel.

**Ques. 2.188.** What is the chemical composition of the electrolyte used in an Edison-type storage cell?

*Ans.* A 21 per cent solution of potassium hydroxide mixed with distilled water to which is added a small amount of lithium hydrate.

**Ques. 2.189.** What is the chemical composition of the electrolyte of a lead-acid storage cell?

*Ans.* A dilute solution of sulphuric acid mixed with distilled water. Specific gravity at full charge, 1.250.

**Ques. 2.190.** Why is a 45-volt dry-cell B battery generally considered unsatisfactory for use when the terminal voltage has fallen to approximately 36 volts?

## RADIO OPERATING QUESTIONS AND ANSWERS

*Ans.* The internal resistance of a cell increases as the cell discharges. When the cell has discharged to the point where its terminal voltage has decreased 20 per cent under load the cell becomes noisy and erratic in operation. Hence, it is considered unsatisfactory and should be replaced.

**Ques. 2.191.** What is "polarization" as applied to a primary cell and how may its effect be counteracted?

*Ans.* "Polarization" is the formation on the surface of the positive electrode of a cell of a film of hydrogen bubbles. This film sets up a counter e.m.f. which results in a so-called "polarization current." Polarization also increases the resistance between the electrolyte and the positive plate resulting in a further decrease in the capacity of the cell. The effects of polarization can be minimized by the use of a depolarizing agent. The depolarizer, when the electrolyte is sulphuric acid, may be cupric sulphate, or, if the electrolyte is sal ammoniac, manganese dioxide.

**Ques. 2.192.** Describe three causes of a decrease in capacity of an Edison-type storage cell.

*Ans.* 1. Allowing the temperature to go above 115 degrees Fahrenheit.  
2. The aging of the electrolyte.  
3. The adding of impure water to replace that lost by evaporation.

**Ques. 2.193.** What is the cause of the heat developed within a storage cell under charge or discharge condition?

*Ans.* Charging or discharging the cell at too high a rate, raising the  $I^2R$  drop.

**Ques. 2.194.** How should sulphuric acid and water be mixed, if it becomes necessary to do so in order to replace lost electrolyte?

*Ans.* The acid should always be poured into the water slowly while the mixture is being stirred with a wooden paddle. It is preferable that electrolyte be mixed in a glass, earthenware, or lead container. Electrolyte should never be mixed in a metallic container other than lead.

**Ques. 2.195.** How may a dry cell be tested to determine its condition?

*Ans.* By a voltage test under normal full-load conditions.

**Ques. 2.196.** What will be the result of discharging a lead-acid storage cell at an excessively high current rate?

*Ans.* The only damage from a too heavy discharge rate is to the connecting leads and wires. The battery itself will not be affected unless overdischarged.

**Ques. 2.197.** What is the approximate fully charged voltage of an Edison storage cell?

*Ans.* 1.37 volts.

**Ques. 2.198.** A 6-volt storage battery has an internal resistance of 0.01 ohm. What current will flow when a 3-watt, 6-volt lamp is connected?

*Ans.* The internal resistance is neglected. It may be assumed that the question reads, what current flows through a 3-watt, 6-volt lamp. Solution:

$$I = \frac{W}{E} = \frac{3}{6} = 0.5 \text{ ampere}$$

**Ques. 2.199.** What is the approximate fully charged voltage of a lead-acid cell?

*Ans.* 2.10 volts.

**Ques. 2.200.** Why is low internal resistance desirable in a storage cell?

## *RADIO OPERATING QUESTIONS AND ANSWERS*

*Ans.* The capacity of the cell is determined, in part, by its internal resistance. Therefore, the lower the internal resistance, the greater will be the capacity of the cell.

**Ques. 2.201.** What is "local action" and how may its effects be counteracted?

*Ans.* "Local action" is that phenomenon whereby small internal currents are set up on the surface of the cell's electrodes by e.m.fs. developed between the active material of the electrode and impurities in that active material. In the dry cell, local action is counteracted by amalgamating the zinc plate with mercury; in acid batteries by trickle charging.

**Ques. 2.202.** What is meant by the term "sulphation" as applied to a lead-acid storage cell?

*Ans.* "Sulphation" is the chemical action on the plates of the cell caused by the breaking up of sulphuric acid molecules ( $H_2SO_4$ ), which combine with the active materials, lead dioxide ( $PbO_2$ ) and sponge lead ( $Pb$ ) to form lead sulphate ( $PbSO_4$ ). This lead sulphate fills in the pores on the surface of the active material and prevents a maximum contact with the electrolyte, thus decreasing the capacity of the cell.

Sulphation is greatly increased when the battery is on discharge, and will continue to increase as long as discharge carries on. Sulphation in itself is not serious unless it is allowed to proceed to the point where active interference with the functioning of the cell is present.

**Ques. 2.203.** How may the condition of charge of an Edison cell best be determined?

*Ans.* Inasmuch as the specific gravity of the electrolyte of the Edison cell does not vary during charge and discharge, the only practical method of ascertaining the condition of charge in the Edison cell is to take a voltage reading under normal load conditions. An ampere-hour meter, if available on the

charging panel, will show directly the amount of change in a battery.

**Ques. 2.204.** If the charging current through a storage battery is maintained at the normal rate, but its polarity is reversed, what will result?

*Ans.* It is obvious that the battery would then be in series with the charging generator instead of being parallel to it. Hence, the battery would be discharged instead of charged. In time, severe sulphation would result and the battery might be ruined.

**Ques. 2.205.** What are the effects of sulphation?

*Ans.* When a cell discharges, sulphate of lead is being formed on the plates. When the cell is charged, this sulphate of lead is forced back into the electrolyte. If the charging process is discontinued before all of the sulphate of lead is reconverted, a residue will remain. When the next discharge cycle occurs, this residue will be present in addition to the newly formed sulphate of lead. If, then, again the recharging process is not sufficient to reconvert all of the lead sulphate, a condition will be reached where an excessive amount of sulphate of lead is on the surface of the plate. The cell is then said to be "sulphated." The effects of sulphation are lowered cell capacity and output voltage.

**Ques. 2.206.** How may the state of charge of a lead-acid storage cell be determined?

*Ans.* There are three methods of testing a lead cell for state of charge, as follows:

1. Observe the reading of the ampere-hour meter.
2. Take a specific gravity reading of the electrolyte with a hydrometer.
3. Measure the voltage of the battery under load. The first two tests are most desirable.

**Ques. 2.207.** With respect to its use in connection with direct-current motors and generators, what is the meaning of the term "neutral position"?

*Ans.* The term "neutral position" refers to the position of the brushes on a direct-current motor or generator for sparkless commutation. It is the point at which the self-induction of the armature coil in contact with the brush is minimum. This accounts for the minimum sparking at this point. When the current in the armature is zero, the neutral position is half-way between the two adjacent poles. When current is flowing, the neutral position moves forward in a generator in the direction of rotation; in a motor, the neutral position is moved backward from the direction of rotation.

**Ques. 2.208.** Why is laminated iron or steel generally used in the construction of the field and armature cores of motors and generators instead of solid metal?

*Ans.* To reduce eddy currents. If a solid core were used, excessive heating would result from the unhindered formation of eddy currents throughout the entire core material. By using laminated iron or steel, the formation of eddy currents is retarded to a negligible value.

**Ques. 2.209.** What is meant by the "regulation" of a generator or alternator?

*Ans.* The "regulation" of a generator may refer to its speed or to its terminal voltage and is the change in either occurring between any two loads. The regulation of a generator is usually expressed as a percentage of the rated *load* value. The A.I.E.E. "Standards" specify regulation as follows: In constant-potential alternators the regulation is the rise in voltage (when specified load at a specified power factor is reduced to zero) expressed in per cent of the rated voltage.

**Ques. 2.210.** What is the purpose of commutating poles or interpoles in a direct-current motor?

*Ans.* Commutating poles are provided to counteract the self-induction in the armature coil, which is in contact with the brush. This reduces sparking at the brushes to a minimum because the reversal of current in the armature comes while the armature coils are still short-circuited by the brush, and the self-induction effect present is low.

**Ques. 2.211.** How may the output voltage of a separately excited alternating-current generator, at constant output frequency, be varied?

*Ans.* This may be accomplished by varying the excitation voltage through the medium of a variable rheostat (resistance) in series with the field.

**Ques. 2.212.** If the field of a shunt-wound direct-current motor were opened while the machine was running under no load, what would be the probable result(s)?

*Ans.* If the field of a shunt-wound machine is opened while the machine is running, the counter e.m.f., ordinarily generated in the armature by the field, disappears with the result that the machine will race badly and possibly damage itself by its excessive speed. The armature may burn out.

**Ques. 2.213.** Name four causes of excessive sparking at the brushes of a direct-current motor or generator.

*Ans.* There are many causes for excessive sparking at the brushes of a direct-current machine as follows:

1. Overloaded.
2. Poor brush fitting or worn brush.
3. Open in armature circuit.
4. High commutator bar.
5. Dirty commutator.
6. Too rapid starting.
7. Brushes off neutral point.

## *RADIO OPERATING QUESTIONS AND ANSWERS*

**Ques. 2.214.** What is the purpose of a commutator on a direct-current motor? On a direct-current generator?

*Ans.* On a motor, the purpose of the commutator is periodically to apply the correct polarity of current flow to each armature coil. On a generator, the purpose of the commutator is periodically to reverse the polarity of the output voltage. The commutator is effectively a rectifier.

**Ques. 2.215.** What is meant by "counter e.m.f." in a direct-current motor?

*Ans.* The "counter e.m.f." in a direct-current motor is the e.m.f. induced in the armature winding when it rotates in the motor field. The counter e.m.f. is of opposite polarity to the applied e.m.f. Therefore, it acts as a limiting device on the speed of the machine.

**Ques. 2.216.** What determines the speed of a synchronous motor?

*Ans.* The frequency of the alternating current ( $f$ ) supplied to the motor and the number of its poles ( $P$ ). ( $S = 120f/P$  r.p.m.)

**Ques. 2.217.** Describe the action and list the main characteristics of a shunt-wound direct-current motor.

*Ans.* The principal characteristic of the shunt-wound motor is that it will maintain a fairly constant speed under varying load conditions. The action is that when the motor has reached full speed without load, the counter e.m.f. is almost the same as the e.m.f. supplied to the motor. Hence, the motor is drawing a minimum current. As soon as a load is applied to the motor, it tends to slow down, but as it does so the counter e.m.f. becomes less, which compensates for the load drag by allowing the machine to increase its speed.

**Ques. 2.218.** Describe the action and list the main characteristics of a series direct-current motor.

*Ans.* The series motor is used where starting under load is necessary, such as in a street car. The load should never be removed from a series motor. To do so would allow the motor to race and tear itself to pieces. In general, the characteristics of the series motor are: quick starting, high speed, and variable speed under shifting load conditions.

**Ques. 2.219.** Describe the action and list the main characteristics of a series direct-current generator.

*Ans.* The field of the series direct-current generator is in series with its armature. Hence, it must carry the full-load current delivered by the machine. For this reason, the field consists of a few turns of heavy wire. The principal characteristic of the series direct-current generator is variable output voltage under variable load conditions, that is, the output voltage depends on the amount of load the machine is carrying. Because of this characteristic the series direct-current generator has practically no useful applications.

**Ques. 2.220.** To obtain an output frequency of 60 cycles per second, a 6-pole alternator must be driven at what number of r.p.m.?

*Ans.* 1,200 revolutions per minute. This figure is arrived at as follows:

$$f = p \times s,$$

$$s = \frac{f}{p} = \frac{60}{3} = 20 \text{ r.p.s. or } 1,200 \text{ r.p.m.}$$

where  $f$  = frequency.

$p$  = pairs of poles.

$s$  = speed in revolutions per second.

**Ques. 2.221.** Describe the action and list the main characteristics of a self-excited shunt direct-current generator.

## *RADIO OPERATING QUESTIONS AND ANSWERS*

*Ans.* The action of a shunt-wound self-excited direct-current generator is as follows: As soon as the armature starts to rotate, the residual magnetism in the field induces an e.m.f. in the armature, which tends to increase the field flux. As the armature continues to rotate, the e.m.f. in the armature increases and a current is caused to flow. If the generator is connected to a load, the current will divide itself, part of it flowing through the load, and part through the generator field. The field winding, being of high resistance, draws only a small amount of current. Hence, the rest of the current flows through the load. The shunt-wound type of generator may be considered a constant potential generator under continuous load, although the voltage output falls slightly as the load is increased.

**Ques. 2.222. Describe the action and list the main characteristics of a flat-compounded direct-current motor.**

*Ans.* The action of the flat- or differentially-compounded motor is best explained by considering its construction. This type of motor is essentially a shunt motor to which a series field has been added and so connected that it opposes the main (shunt) field. The armature is connected across the shunt field.

The main characteristic of the flat-compounded motor is that it has a more nearly constant speed under widely varying load conditions than any other type of motor. This desirable characteristic is brought about by the action of the series field. As the load on this motor increases, the current through its armature increases. The motor then tends to slow down and to draw a heavier current from the line. When this occurs a heavier current flows through the series field. But this field opposes the shunt field with the net result that the total field is weakened. This weaker field allows the armature to draw more current and speed up. In this way the tendency of the motor to slow down under load is neutralized and a fairly constant speed maintained.

**Ques. 2.223.** What is the output frequency of a generator having 10 poles and revolving at 1,200 r.p.m.?

*Ans.* 100 cycles, computed as follows:

$$f = p \times s = 5 \times 20 = 100 \text{ cycles.}$$

(See Ques. 2.220.)

**Ques. 2.224.** How may the direction of rotation of a shunt direct-current motor be reversed?

*Ans.* The direction of rotation of a shunt direct-current motor may be reversed by reversing the leads of either the armature or the field terminals, not both.

**Ques. 2.225.** Why are series motors not used for motor-generator sets?

*Ans.* Series motors have a variable speed characteristic under variable load conditions, such as are encountered in radio power-supply circuits. Hence, the series motor is not suitable for use in motor-generator sets.

**Ques. 2.226.** Why is carbon commonly used as a brush material?

*Ans.* Carbon brushes are satisfactory for small machines where the load does not exceed 35 amperes. Carbon is very satisfactory as a brush material because the face of a carbon brush soon wears down to form a good contact with the commutator. Carbon has the further advantage of disintegrating in the form of a very fine powder, which does not short-circuit the segments of the commutator. Carbon also tends to polish the surface of the commutator and works to assist any commutator compound which might be used to keep the surface of the commutator clean. Carbon is also a slow-wearing material and is, therefore, economical for use as a brush.

**Ques. 2.227.** If a self-excited direct-current generator failed to build up to normal output voltage when running at normal speed, what might be the cause and how could it be remedied?

*Ans.* The cause might be low or reversed residual magnetism in the field poles. The remedy for this condition is to remagnetize the field poles by exciting them separately until they have resumed their former magnetic strength.

**Ques. 2.228.** A transformer having a split secondary is used with a full-wave rectifier with the transformer center tap for the common negative return; if the same transformer was connected for full-wave bridge rectification, what would be the effect upon the output voltage?

*Ans.* The output voltage would be doubled.

**Ques. 2.229.** If a high-voltage rectifier system was changed from a full-wave, center-tapped transformer connection to a bridge-connected, full-wave rectifier system using the same high-voltage transformer, what changes in the filter components would be necessary?

*Ans.* As under these conditions the output voltage would be doubled, the voltage rating of the filter components would necessarily have to be doubled. Allowance would also have to be made in the choke coils for any increase in power output caused by this raise in voltage.

**Ques. 2.230.** List the main advantages of a full-wave rectifier as compared with a half-wave rectifier.

*Ans.* The main advantages of a full-wave rectifier, as compared to a half-wave rectifier, are that the ripple frequency of the full-wave rectifier is double that of the half-wave rectifier. Consequently, the filtering arrangements need not be so extensive. This usually means that the cost of the filter can be reduced. Another advantage of the full-wave rectifier is that the noise level, under a given set of conditions, can nearly always be reduced to a lower level with the full-wave rectifier than with the half-wave rectifier.

**Ques. 2.231.** Using a plate transformer having a secondary voltage of 500 volts r.m.s., in a single-phase half-wave rectifier working into a condenser input filter, what should be

the minimum allowable working voltage direct-current rating for the filter input condenser?

*Ans.* The condenser must stand a peak voltage which is equal to 1.414 times the r.m.s. value. In this problem the peak value would be 707 volts. In practice a 2,000-volt condenser would be used on this job.

**Ques. 2.232.** A single-phase power transformer, with secondary center tapped, has a total secondary voltage of 2,000 volts r.m.s. When used in a full-wave rectifying circuit and condenser input filter, the filter input condenser should have what continuous operating direct-current voltage rating?

*Ans.* The condenser must stand a peak voltage of 1,414 volts, computed as in the preceding answer. In practice a voltage strain of at least 4,000 volts would be allowed for.

**Ques. 2.233.** Why cannot a transformer be used with direct current?

*Ans.* Because it works on the principle of induction, which requires a changing magnetic field surrounding the secondary.

**Ques. 2.234.** Draw a simple schematic diagram of a half-wave, three-phase rectifier system.

*Ans.* See Fig. 2-38.

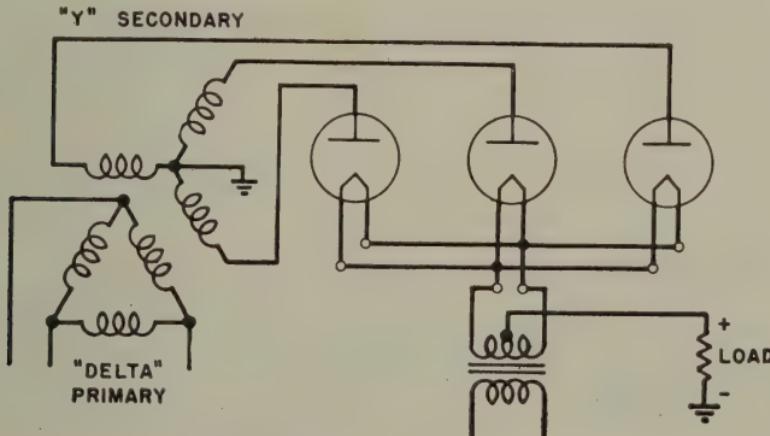


FIG. 2-38.—Half-wave three-phase rectifier.

**Ques. 2.235.** What are the primary advantages of a high-vacuum rectifier as compared with the hot-cathode mercury-vapor rectifier?

*Ans.* The principal advantages of the high-vacuum rectifier are that it may have higher maximum-peak, inverse-voltage and power-output ratings. Although the voltage regulation of the high-vacuum type rectifier is not so satisfactory as the hot-cathode mercury-vapor rectifier, the high-vacuum rectifier will stand a greater amount of abuse under high-power load conditions than will the mercury-vapor type. This is particularly true of the filaments in these tubes, the mercury-vapor tube's filament being susceptible to each damage under improper operating conditions.

**Ques. 2.236.** What are the primary characteristics of a gas-filled rectifier tube?

*Ans.* This type of amplifier tube operates upon the principle of "ionization due to collision." Some of its characteristics are as follows:

1. High current-carrying ability.
2. Low and constant voltage drop while conducting.
3. Good voltage regulation.
4. Cathode easily damaged by overload.
5. "Flash-back" will result from excessive inverse peak voltages.
6. Must be used with choke-input filter to limit starting current.
7. Steep current wave fronts produce radio-frequency and audio-frequency "hash" which must be filtered to reduce interference.

**Ques. 2.237.** What are the primary advantages of a mercury-vapor rectifier as compared with the thermionic high-vacuum rectifier?

*Ans.* The primary advantage of a mercury-vapor rectifier is that it has a voltage drop in the tube of only 15 volts under normal operating conditions, regardless of load. The voltage drop in the high-vacuum rectifier tube varies with the load conditions. Because of the low drop in the mercury-vapor type, there is less heat dissipated in the tube and the tube, therefore, is usually self-cooling. On the other hand, owing to the high-voltage drop under heavy load conditions in the high-vacuum type of rectifier, the tube must dissipate a considerable amount of heat. This makes it necessary to use a water jacket on the high-power type of tube. Also, because of the low internal voltage drop in the mercury-vapor rectifier tube, the voltage regulation is better with this tube than it is with the high-vacuum type. High-vacuum type rectifier tubes are used in both receivers and transmitters. Water-cooling is only necessary, of course, in the high-power transmitter types.

**Ques. 2.238.** Why is it desirable to have low-resistance filter chokes?

*Ans.* The lower the resistance of the filter chokes, the less the voltage drop around these chokes and the greater the value of voltage available at the output terminals.

**Ques. 2.239.** Why is it necessary to use choke-input filter systems in connection with mercury-vapor rectifier tubes?

*Ans.* To limit the initial current surge applied to the rectifier tubes, thus preventing damage to the filaments of the tubes.

**Ques. 2.240.** What are the primary characteristics of a choke-input filter?

*Ans.* The choke input filter system, as used with mercury-vapor rectifier tubes, includes a first choke (input choke)

## RADIO OPERATING QUESTIONS AND ANSWERS

which functions to prevent current peaks from going high enough to damage the filament of the rectifier tubes. Because of this steadyng effect on the current, the regulation of the system as a whole is improved.

**Ques. 2.241.** What are the primary characteristics of a condenser input filter?

*Ans.* High output voltage with poor regulation.

**Ques. 2.242.** What is the primary purpose of a swinging choke in a filter system?

*Ans.* The swinging choke provides an inductance value which varies inversely with the current flow, thereby improving the regulation of the power supply. This is achieved by a small air gap which permits saturation with heavy current flow, with a consequent decrease in inductance.

**Ques. 2.243.** Why does the output of a direct-current generator generally require less filtering than the output of a rectifier system?

*Ans.* Because the ripple frequency is much higher and the ripple amplitude is much lower. The ripple frequency depends upon the number of segments in the commutator and the speed of the machine.

**Ques. 2.244.** When filter condensers are connected in series, resistors of high value are often connected across the terminals of the individual condensers. What is the purpose of this arrangement?

*Ans.* To distribute the voltage strain evenly between the condensers and to discharge the condensers after shutdown.

**Ques. 2.245.** Draw a diagram of a bridge type, single-phase, rectifier employing mercury-vapor type tubes and connected to a choke input, two-section filter system, including a bleeder resistance.

Ans. See Fig. 2-39.

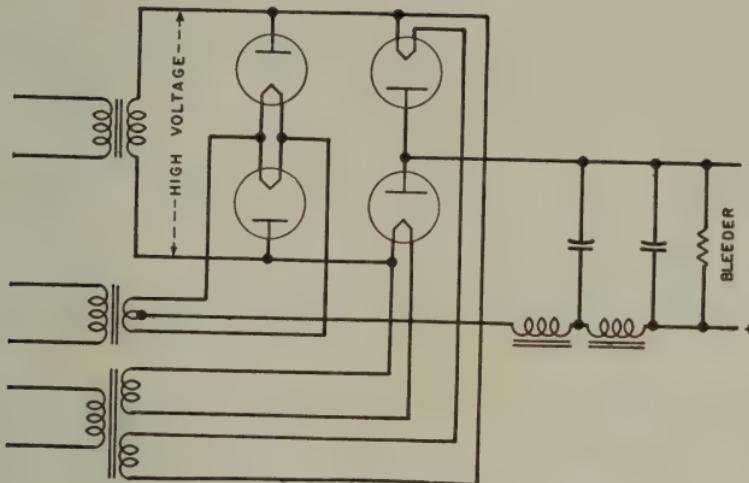


FIG. 2-39.—Bridge rectifier, single phase.

Ques. 2.246. Draw a diagram of a full-wave, single-phase rectifier employing thermionic vacuum tubes, connected to a condenser input, two-section filter system, and including a bleeder resistance.

Ans. See Fig. 2-40.

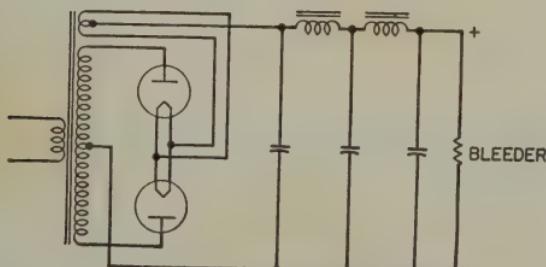


FIG. 2-40.—Full-wave single-phase rectifier.

**Ques. 2.247.** Draw a diagram of a half-wave rectifier system employing thermionic rectifier tubes and a two-section, condenser input, filter system.

*Ans.* See Fig. 2-41.

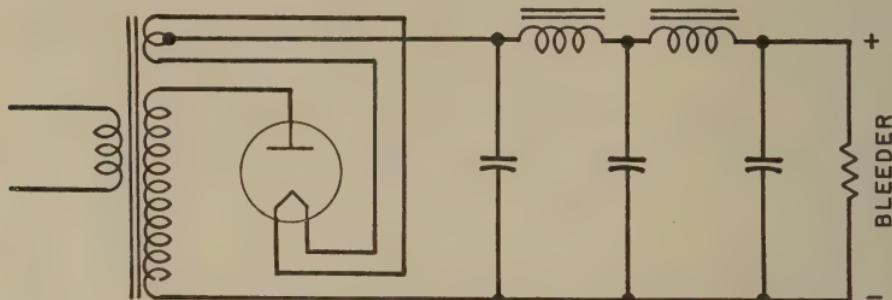


FIG. 2-41.—Half-wave rectifier.

**Ques. 2.248.** What is the primary purpose of a bleeder as used in a filter system?

*Ans.* The purpose of a bleeder as used in a filter system is to improve the regulation of the system. The bleeder also serves to discharge the filter condensers after shutdown, thus providing protection to the personnel against shock.

**Ques. 2.249.** If the frequency of the supply source is 60 cycles, what is the output ripple frequency of a three-phase full-wave rectifier?

*Ans.* Ripple frequency =  $(60 \times 3 \times 2) = 360$  cycles.

**Ques. 2.250.** If the frequency of the supply source is 60 cycles, what is the output ripple frequency of a single-phase full-wave rectifier?

*Ans.* 120 cycles.

**Ques. 2.251.** If the plates of a full-wave high-vacuum rectifier tube become red hot while in operation, what may be the cause(s) of this condition?

*Ans.* Short-circuited filter condensers, or excessive external load, which might be caused by improper adjustment of the

radio-frequency circuit to which the rectifier tube supplies power.

**Ques. 2.252.** List the primary characteristics of a high-voltage plate supply as compared to a low-voltage plate supply, considering the capacity of the filter condensers required to provide a given degree of filtering.

*Ans.* For a low-pass filter condenser the value of  $C$  chosen varies directly with current drain and inversely with ripple frequency; that is,  $C = 0.3183/f_c R$ , where  $C$  is in farads,  $f_c$  is the frequency at which attenuation begins, and  $R$  is the load resistance. The high-voltage supply would probably need a larger capacity to take care of the larger current drain.

**Ques. 2.253.** How may radio-frequency interference from gaseous rectifier tubes be minimized?

*Ans.* By enclosing the rectifier tube in a grounded shield can be placed over each rectifier tube and a radio-frequency choke in each plate lead at the rectifier tube socket.

**Ques. 2.254.** What is the primary purpose for having choke input to a filter when using mercury-vapor-type rectifier tubes?

*Ans.* The choke-input filter system, as used with mercury-vapor rectifier tubes, includes a first choke (input choke) which functions to prevent current peaks from going high enough to damage the filament of the rectifier tubes. Because of this steadyng effect on the current, the regulation of the system as a whole is improved.

**Ques. 2.255.** Describe the construction and characteristics (1) of a thermocouple type of meter; (2) of a wattmeter.

*Ans.* 1. The thermocouple type of meter consists of two parts: (a) the thermocouple, (b) a D'Arsonval meter movement. The thermocouple generates a current propor-

tional to the current being measured. The current generated by the thermocouple is then measured by the meter movement to which the thermocouple is electrically connected. The thermocouple may be located in the same case with the meter movement or the thermocouple may be separate from the meter and connected to it by lead wires. The thermocouple consists of two different metals, usually in the form of wires crossed at right angles. Various types of metals may be used for the thermocouple element, the most common being constantan, bismuth, and antimony brought together under pressure. The thermocouple ammeter may be used to measure radio-frequency currents, regardless of frequency. In practice, the thermocouple unit must be connected directly in the circuit under measurement.

2. The mechanism of the electrodynamometer-type wattmeter consists of a set of fixed "current coils" which connect in series with the line, and a moving "potential coil" which connects in parallel to the line. A reaction between the fixed coils and the movable coil causes a movement of the latter which is proportional to the power flowing in the circuit. Instantaneous values of watts being expended in the circuit are indicated directly on a scale over which a pointer, attached to the movable coil, swings. See Fig. 4-1.

The wattmeter is used only on alternating-current circuits, power readings on direct-current circuits being generally more accurate when computed from instantaneous current and voltage readings. The power expended in alternating-current circuits containing inductance or capacity, or both, is dependent on the current, voltage, and power factor involved. The wattmeter automatically integrates the power curve and multiples it by the power factor of the circuit, giving a direct reading in watts being expended.

The necessary connections from the coils in the wattmeter are brought out to three or four terminal posts depending on the style of wattmeter. A current-limiting resistor is always provided in series with the moving coil, which is connected across the line. This resistance is generally placed inside the meter case and is an integral part of the instrument.

**Ques. 2.256.** Describe the construction and characteristics of a D'Arsonval type of meter.

*Ans.* The D'Arsonval movement depends for its operation on the torque produced on a rotating armature by a field of force. Torque developed by the armature is balanced against the force of a spring which resists the rotation of the armature. The armature is fixed to revolve between the poles of a permanent magnet and is comparable in operating principle to a small electric motor.

The terminals of the armature are connected across the potential to be measured. When the current flows in the armature, it tends to orient itself with respect to the permanent magnet between which it is placed to revolve. A pointer is attached to the armature. As the armature revolves, the pointer moves across a scale, which indicates the meter reading.

The D'Arsonval movement, also known as the "moving-coil" type of meter, can be used as an ammeter or as a voltmeter. When it is used as a voltmeter and connected directly across the line, a current-limiting resistor must be connected in series with the armature. When a reading higher than that of the calibrated meter is desired, a series resistor, called a *multiplier*, may be used to increase the range of the D'Arsonval movement used as a voltmeter. This multiplier is in addition to the before-mentioned current-limiting resistor, which is usually located inside the meter case.

When the D'Arsonval movement is used as an ammeter, its range may be increased by connecting across its terminals a conductor of known resistance, called a *shunt*.

The D'Arsonval movement must be calibrated for use with a particular multiplier or shunt. If the length of the lead wires connecting the multiplier or shunt to the meter is changed, the calibration of the meter will be changed.

**Ques. 2.257.** Describe the construction and characteristics of a repulsion-type ammeter.

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ans.** A repulsion type of meter is the iron-vane type meter, which consists of two pieces of soft iron bent concentrically and placed within a coil. When the coil is energized, it magnetizes both pieces of iron in the same direction with the result that they repel one another, resulting in a movement of the movable vane. The extent of the movement depends on the amount of excitation produced by the coil. A pointer is attached to the movable element which passes in front of a calibrated scale. As the reversals of magnetization due to the alternating current occur in the coil, the iron vanes are also reversed in polarity and the deflection factor remains constant regardless of polarity. It is possible, therefore, to use this type of movement on an alternating-current circuit.

**Ques. 2.258. Describe the construction and characteristics of a dynamometer-type indicating instrument.**

**Ans.** The dynamometer type depends for its action on the reaction produced between a movable coil and a stationary coil, or between a movable coil mounted between two fixed coils. This type of meter, like the repulsion type of meter previously described, is limited to use on commercial frequencies only and cannot be used to measure radio frequencies. An indicating unit is attached to the movable coil. Hence, when the movable coil moves, the indicating unit, a pointer moving over a scale or a calibrated disc or drum, indicates the current or power being measured. See Fig. 6-1.

**Ques. 2.259. Describe the construction and uses of an ampere-hour meter.**

**Ans.** A common type of ampere-hour meter used with storage-battery equipments is the Sangamo ampere-hour meter. Its function is to indicate the state of charge and discharge of the batteries. It is mounted in a cubical case and has a circular dial face on which the ampere-hour units are marked. The dial moves clockwise during discharge and counterclockwise during charge. A special contact is provided

so that when the batteries are fully charged a contact trips the circuit breaker and opens the charging circuit.

The mechanism of the meter consists of a mercury-type motor consisting of a copper disc floating in mercury and a small field-coil winding which is stationary. By connecting a revolution counter to this motor, a means is provided for recording the total quantity of energy that has passed.

**Ques. 2.260. Describe the construction and characteristics of a hot-wire type indicating instrument.**

*Ans.* The hot-wire ammeter utilizes for its operation the expansion characteristic of a thin, platinum-silver-alloy wire when subjected to the heating effect of a current to indicate current flow. The principal disadvantage of this type of meter is that the alloy wire on which the instrument depends for its operation will burn out at a very slight overload. In addition, the hot-wire ammeter is not very accurate and will not retain its calibration in varying temperatures. The meter also has a considerable time lag and requires several seconds after the application of the current to register.

**Ques. 2.261. Why is constantan wire often used in the construction of voltmeter multiplier resistors?**

*Ans.* Constantan is an alloy of copper and nickel. It is used for multiplier resistors because it has an extremely low temperature coefficient, which is on the order of zero change in the range from 0 to 100 degrees centigrade.

**Ques. 2.262. A voltmeter is described as having "1,000 ohms per volt." What current is required to produce full-scale deflection?**

*Ans.* Assuming the full-scale deflection to be 100 volts, the total resistance of the meter would be 100,000 ohms. Hence, according to Ohm's law, 1 milliampere would produce full-scale deflection.

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 2.263.** If two voltmeters are connected in series, how would you be able to determine the total drop across both instruments?

*Ans.* The total voltage drop across both instruments would be the sum of the individual meter readings.

**Ques. 2.264.** What type of meters may be used to measure radio-frequency currents?

*Ans.* The thermocouple ammeter and the hot-wire ammeter.

**Ques. 2.265.** If two voltmeters are connected in parallel, how may the total voltage drop across both instruments be determined?

*Ans.* The total voltage drop across both instruments would be the reading of either one of the meters.

**Ques. 2.266.** How may the current indicating range of a thermocouple be increased?

*Ans.* By inserting a multiplier resistance in series with the lead from the thermocouple to the meter. A shunt, if very carefully proportioned, may also be used around the thermocouple to increase its range.

**Ques. 2.267.** Why are copper oxide rectifiers, associated with direct-current voltmeters for the purpose of measuring alternating current, not suitable for the measurement of voltages at radio frequencies?

*Ans.* Copper oxide rectifiers are not suitable for the measurement of voltages at radio frequencies because at these frequencies the capacity of the rectifier unit would pass the radio-frequency current without rectification, thus making the reading inaccurate.

**Ques. 2.268.** If two ammeters are connected in parallel, how may the total current through the two meters be determined?

*Ans.* The total current through two ammeters connected in parallel is the sum of the individual meter readings.

**Ques. 2.269.** Is the angular scale deflection of a repulsion iron-vane ammeter proportional to the square or square root of the current, or merely directly proportional to the current?

*Ans.* The scale deflection of a repulsion iron-vane ammeter is proportional to the square of the current.

**Ques. 2.270.** Does an alternating-current ammeter indicate peak, average, or effective values of current?

*Ans.* An alternating-current ammeter, exclusive of copper oxide types, indicates the effective value of current.

**Ques. 2.271.** If two ammeters are connected in series, how may the total current through the two meters be determined?

*Ans.* The total current through two ammeters connected in series is the average of the individual meter readings.

**Ques. 2.272.** Given a milliammeter of full-scale deflection equal to 1 milliampere, and an internal resistance of 50 ohms, what value of shunt resistance must be connected across the meter terminals to permit full-scale deflection at a current value of 51 milliamperes?

*Ans.* 1 ohm, computed as follows:

$$R_s = \frac{I_a}{I_s} \times R_a = \frac{0.001}{0.05} \times 50 = 1 \text{ ohm.}$$

**Ques. 2.273.** Given a milliammeter of full-scale deflection equal to 1 milliampere, and an internal resistance of 50 ohms, what value of additional series resistance must be used to permit operation as a voltmeter with a full-scale deflection at 70 volts?

*Ans.* 69,950 ohms, computed as follows:

$$R = \frac{E}{I} = \frac{70}{0.001} = 70,000 - R_m = 69,950 \text{ ohms.}$$

**Ques. 2.274.** How may a direct-current milliammeter, in an emergency, be used to indicate voltage?

*Ans.* By using it in series with a resistor of known value. This resistor must be of a value sufficiently great so that an excessive current will not flow through the meter and burn it out. The formula for figuring the value of the multiplier is as follows:

$$R = \frac{E_1 - E_2}{I} \text{ ohms,}$$

where  $E_1$  is the full-scale deflection desired.

$E_2$  is the voltage drop in the meter for full-scale deflection.

$I$  is the current flow in the meter for full-scale deflection.

**Ques. 2.275.** What is the purpose of multiplier resistance used with a voltmeter?

*Ans.* The purpose of the multiplier resistance, as used with a voltmeter, is to increase the range of the meter.

**Ques. 2.276.** What are the limitations on the use of copper oxide rectifiers used with direct-current meters?

*Ans.* Copper oxide rectifiers, as used with direct-current meters, can only be used on the commercial frequencies or frequencies extending into the lower range of audio frequencies. Copper oxide rectifiers cannot be used with meters used to measure radio-frequency currents because the capacity of the rectifier unit would pass the radio-frequency current, thus making the meter reading inaccurate.

**Ques. 2.277.** What type of indicating instrument is best suited for use in measuring radio-frequency currents?

*Ans.* The thermocouple type of radio-frequency ammeter.

**Ques. 2.278.** What is the purpose of a shunt as used with an ammeter?

*Ans.* The purpose of a shunt as used with an ammeter is to increase the indicating range of the instrument.

**Ques. 2.279.** What effects might be caused by a shorted grid condenser in a three-circuit regenerative receiver?

*Ans.* A shorted grid condenser in a three-circuit regenerative receiver would short-circuit the grid leak. Then the application of a signal voltage would not cause an audio-frequency variation in grid potential because the grid would have on it at all times a charge equal to the space charge. The result would be that the detector would not function as a rectifier or as a detector and would be inoperative.

**Ques. 2.280.** What would be the effect of a short-circuited coupling condenser in a conventional resistance-coupled audio amplifier?

*Ans.* The effect of a short-circuited coupling condenser in a conventional resistance-coupled audio amplifier would be to allow the grid of the following tube to become positively biased, causing heavy grid and plate currents to flow. Under these conditions a continuous grid current and heavy plate current will flow, which completely alters the linearity of the operating curve. In addition, the heavy  $I$ - $R$  drops in the plate circuit will result in a great decrease in plate potential and volume.

**Ques. 2.281.** What might be the faults which make a regenerative receiver unable to regenerate or oscillate?

*Ans.* The following conditions might make a regenerative receiver unable to generate or oscillate:

1. Low plate potential.
2. Low filament potential.

3. Reversed operating potentials.
4. Reversed tickler-coil connection.
5. Open-circuited grid leak.
6. Wrong value grid leak.
7. Short-circuited grid condenser.
8. Open circuit somewhere in the secondary or tickler-coil circuits.
9. Poor tube.
10. Insufficient feedback.

**Ques. 2.282.** What would be the effect of an open grid-leak resistance in a three-circuit regenerative receiver?

*Ans.* The receiver would fail to oscillate or regenerate and would not operate. "Motorboating" would occur.

**Ques. 2.283.** What might be the cause of low sensitivity of a three-circuit regenerative receiver?

*Ans.* Low sensitivity of a three-circuit regenerative receiver is generally caused by low plate potential, reversed tickler-coil connections, wrong value grid leak, or a deactivated or otherwise defective tube.

**Ques. 2.284.** If the plate current of a vacuum tube changed 5 milliamperes for a grid voltage change of 2.5 volts, what is the value of transconductance?

*Ans.* The value of transconductance would be 2,000 micromhos, computed according to the formula

$$S_m = \frac{\text{change in plate current}}{\text{change in grid voltage}}$$

**Ques. 2.285.** In a self-excited, grid-leak type oscillator without cathode bias, what would result if oscillations cease?

*Ans.* The operating bias would be automatically removed, the plate current would rise, possibly to damaging proportions, and the tube might be ruined.

**Ques. 2.286.** In a shunt-fed plate circuit of a vacuum-tube amplifier, what would result if the plate radio-frequency choke developed a short circuit?

*Ans.* An impedance equal to the resistance of the power supply to ground would be connected in shunt with the plate tank circuit, thus throwing the circuit entirely out of tune. This condition would show up by the improper meter readings produced.

**Ques. 2.287.** In a series-fed plate circuit of a vacuum-tube amplifier, what would result if the plate supply by-pass condenser developed a short circuit?

*Ans.* The positive side of the plate supply would be grounded. The fuses in the power-supply line would then blow or the circuit breakers would trip.

**Ques. 2.288.** In a shunt-fed plate circuit of a vacuum-tube amplifier, what would result if the plate radio-frequency choke developed an open circuit?

*Ans.* The plate potential would be removed, and the tube would be inoperative.

**Ques. 2.289.** In a shunt-fed plate circuit of a vacuum-tube amplifier, what would result if the plate-blocking condenser developed a short circuit?

*Ans.* The plate supply would be grounded through the plate-load impedance, rendering the circuit inoperative. This would show up by incorrect meter readings in a transmitter.

**Ques. 2.290.** What is the effect of local action in a lead-acid storage cell and how may it be compensated?

*Ans.* Local action tends to discharge the cell very slowly. Therefore, over a period of time, the capacity of a cell would be decreased. Local action is prevented as much as possible, (1) by the manufacturer in making the active materials as pure as possible, and (2) by keeping the cells on trickle charge.

## *RADIO OPERATING QUESTIONS AND ANSWERS*

**Ques. 2.291.** Why should adequate ventilation be provided in the room housing a large group of storage cells?

*Ans.* The room housing a large group of storage cells should be well ventilated in order to allow the escape of gas fumes generated during the charging process. Smoking must not be permitted, especially when the batteries are on charge. If covers are provided on the battery boxes, they should be removed during the charging period.

**Ques. 2.292.** When should distilled water be added to a lead-acid storage cell and for what purpose is it added?

*Ans.* Distilled water should be added when the level of the electrolyte has been reduced below normal by evaporation. Distilled water is added because the batteries operate best when the plates are entirely covered by electrolyte.

**Ques. 2.293.** How may the polarity of the charging source to be used with a storage battery be determined?

*Ans.* If a suitable instrument is not at hand, the positive and negative sides of the line may be determined on circuits of 110 volts or less, by dipping the ends of the two wires in a glass of water in which a very small amount of common table salt, potash, or acid electrolyte has been dissolved. Keep the wires about 1 inch apart. When there is current flowing, gas bubbles will form on both wires, but the wire where the greater amount of gas bubbles is being formed will be the negative side of the circuit.

Another method to determine the polarity of the line is to place the two wires about  $\frac{1}{4}$  inch apart on a wet piece of blue litmus paper. Where the positive wire touches the wet paper, a red mark will appear if current is flowing.

When employing these tests the operator must use extreme care not to short-circuit the line or to get himself in contact with both sides of the line at once.

**Ques. 2.294.** Describe the care which should be given a group of storage cells to maintain them in good operating condition.

*Ans.* A battery equipment, regardless of type, should have careful attention. The electrolyte should be kept about  $\frac{1}{2}$  inch above the top of the plates by replacing loss due to evaporation with distilled water. The electrolyte level should never be maintained by replacing acid unless the electrolyte is in some way spilled out. The acid does not evaporate, it being the water in the electrolyte that is so reduced. It is important that the battery be kept fully charged, not only so that it may be ready for immediate use, but also because it is best for the internal condition of the individual cells. The condition of charge of a lead-cell battery may be checked up by taking combined hydrometer and voltmeter readings of the individual cells. If the cells as a whole show comparatively low hydrometer readings, they should be charged. A low-voltage reading indicates the same condition. Radio batteries should be given a check up about once a month. If a cell shows an unnatural condition such as low specific gravity reading and low-voltage reading it may indicate sulphation or plate buckling, and it should be cut out of the circuit by disconnecting the lead-strap connectors and jumping the bad cell. As soon as possible the bad cell should be taken out and repaired. The battery should be promptly recharged when the voltage of the individual cell reaches 1.7 volts, therefore the voltage of the entire bank would read  $1.7 \times$  number of cells. A battery should not be charged more frequently than once a week unless the service requires it. The few simple rules listed below apply to all cells.

1. Keep open flames away from the battery at all times.
2. Replace spilled electrolyte before charging.
3. When water in cell evaporates add distilled or pure water.
4. Never allow cells to remain in discharged condition.
5. Mix electrolyte in clean earthen or glass jars.

## RADIO OPERATING QUESTIONS AND ANSWERS

6. Allow solution to cool before putting into cell.
7. Never pour water into sulphuric acid.
8. Never allow salt to get into cell.
9. Use only absolutely pure chemicals and water.
10. Always provide plenty of ventilation.
11. If burned by sulphuric acid apply ammonium hydroxide or baking soda.
12. Don't charge at a too high rate.
13. Don't discharge at a too high rate.
14. When not in use, keep on trickle charge.
15. Take frequent voltage readings.
16. Take occasional hydrometer readings.
17. Keep the level of the electrolyte about  $\frac{1}{2}$  inch above the plates by adding chemically pure water.
18. Give an overcharge about once a month.
19. Keep the tops of each battery dry to prevent current leakage.
20. Keep all electrical connections free from corrosion by applying a very thin layer of vaseline after the connection has been made.
21. Do not add acid unless some has been lost due to spilling or flooding, and not even then unless the specific gravity reading does not come up to normal after charging.

Oversulphation may be caused by

1. Wrong specific gravity of electrolyte.
2. Overdischarge.
3. Allowing cell to remain too long in a discharged condition.

**Ques. 2.295. What may cause the plates of a lead-acid storage cell to buckle?**

*Ans.* Overdischarge.

**Ques. 2.296. What may cause sulphation of a lead-acid storage cell?**

*Ans.* Sulphation is caused by improper charging over a long period of time. Overdischarge will also cause sulphation.

**Ques. 2.297.** What chemical may be used to neutralize a storage cell acid electrolyte?

*Ans.* Ammonia or sodium bicarbonate, commonly known as baking soda.

**Ques. 2.298.** What steps may be taken to prevent corrosion of lead-acid storage cell terminals?

*Ans.* The terminals should be kept clean and coated with a light coating of vaseline.

**Ques. 2.299.** Why are by-pass condensers often connected across the brushes of a high-voltage direct-current generator?

*Ans.* By-pass condensers are often connected across the brushes of a high-voltage direct-current generator to act as a protective device to protect the generator windings from being punctured should a high-voltage kick-back occur from the high frequency circuits. These condensers are usually made up into a unit consisting of two condensers in series, the outer terminals being connected across the generator and the center terminal to ground.

**Ques. 2.300.** What materials and technique should be used to keep the commutator of a direct-current motor or generator clean?

*Ans.* The commutator of the direct-current motor or generator is kept clean by polishing it with a piece of fine sandpaper, usually No. 0000. Emery cloth should never be used because it contains small metallic dust which would short-circuit the commutator segments. A piece of coarse canvas is also useful in giving the commutator a final polish. A special commutator paste is also available. This paste should be applied sparingly with a clean cloth and the commutator then polished while the machine is running.

**Ques. 2.301.** What may cause a motor-generator bearing to overheat?

## RADIO OPERATING QUESTIONS AND ANSWERS

*Ans.* The bearing of a motor generator may be caused to overheat by the lack of sufficient lubrication. This, in turn, may be caused by a defective oil ring or, in the larger machines, by a defect in the lubricating oil line.

**Ques. 2.302.** How may the radio-frequency interference, often caused by sparking at the brushes of a high-voltage generator, be minimized?

*Ans.* Usually by the use of a ripple filter, consisting of two 1-microfarad condensers and a 10-henry choke. In addition a radio-frequency filter consisting of radio-frequency chokes and radio-frequency by-pass condensers are sometimes used.

**Ques. 2.303.** What may be the effect of shifting the brushes of a direct-current generator from the neutral position?

*Ans.* Shifting the brushes from the neutral position will cause excessive sparking.

**Ques. 2.304.** Describe the treatment which should be given an overheated motor-generator bearing.

*Ans.* A hot bearing always appears when the machine is running, and, therefore, quick action is necessary to prevent damage to the bearings. In the case of a very hot bearing, **do not stop the machine** but slow it down to its slowest speed. If the machine is stopped, the sudden cooling of the bearings will cause them to contract, and they may "freeze" together; that is, the armature shaft or movable bearing may by its expansion fit so tightly into the bell or frame bearings that it cannot be revolved nor the units separated without considerable difficulty and the danger of permanently injuring the bearings.

A satisfactory method of treating a hot bearing is to slow down the machine immediately and apply graphite and machine oil liberally to the hot bearings. Everything possible

should be done to cool the machine. A towel soaked in ice water, wrung out, and applied to the bearing has been effectively used. A blower or fan may be directed against the hot bearing to cool the surrounding air. Doors or vents leading to the open air should be opened to help cool the machine.

When the bearing is cool again, it may be treated by removing the oil and graphite and flushing with kerosene. The machine is, of course, kept running slowly. After the bearing has been flushed, a good grade of lubricating oil should be poured into the bearing for operation. The hot bearing has then been effectively treated, and the machine may be either stopped or again put in operation.

If the hot bearing again occurs, the machine should be dismantled and the bearings carefully inspected for the trouble. It might be necessary to smooth the shaft down in a lathe.

It is only the motor generators having Babbitt-metal bearings which are likely to get hot. Machines equipped with ball bearings rarely give trouble in this way, provided they are regularly greased.

**Ques. 2.305.** What may cause a generator to fail to "build up"?

*Ans.* Lack of residual magnetism in the field poles in a self-excited generator. Open-field excitation circuit in a separately excited generator.

**Ques. 2.306.** For what purpose may a reverse current relay be used?

*Ans.* A reverse current relay is used in conjunction with storage-battery charging circuits to prevent the application of a reversed charging current to the battery. This relay also prevents the battery from discharging back into the generator should the charging voltage fall below that of the battery.

**Ques. 2.307.** Explain the difference in construction and operating characteristics of high- and low-voltage fuses.

*Ans.* The essential difference in construction between the two voltage ranges is in the provision made for break distance. In other words, the higher the voltage, the longer break distance must be provided. By "break distance" is understood the dimension between the parts on which the fusible element is secured. When the break distance is increased, it, of course, follows that the fusible element will be increased in length and, consequently, increased in volume content of fusible material. To compensate for this additional volume, the fuse casing for the high-voltage fuse is made proportionately longer than is that for a fuse of corresponding rating in the low-voltage fuse.

**Ques. 2.308. Explain the uses and limitations of fuses and circuit breakers as used in radio equipment.**

*Ans.* Fuses are made of quick-melting alloys, which, when an excessive current is passed through them, melt and open the circuit. Fuses must be either renewed or replaced when they are blown. The circuit breaker, on the other hand, is a special relay which disconnects the current when it exceeds a certain predetermined value for which the circuit breaker is set. The circuit breaker can be reset when it is tripped. Hence, it is economical in operation, although its first cost is higher than that of the fuse.

Another important difference is that the fuse depends for its operation on the factors  $I^2R$ , which develop the heat to blow the fuse. The fuse has no voltage limit. Also, inasmuch as the resistance factor is a fixed value, the only variable factor determining the operating limits of the fuse is the current flowing through it. The circuit breaker, on the other hand has a voltage limit above which it cannot be used because of the possibility of a breakdown in the insulation of the magnet windings and the inductive effect of these windings at high voltages.

**Ques. 2.309. What is meant by a "polarized relay"?**

*Ans.* A "polarized relay" is one which operates on direct current and contains a permanent magnet. Current of one polarity will attract the relay armature while reversed polarity repells it. Selective double action of the relay can therefore be remotely controlled by controlling the polarity of the operating current.

**Ques. 2.310.** Why are high-reactance head telephones generally more satisfactory for use with radio receivers than low-reactance types?

*Ans.* High-reactance head telephones may be successfully coupled directly into the plate circuit of the output-stage vacuum tube. This is possible because the load on this plate circuit must be equal to at least twice the plate resistance of the tube for distortionless operation. The high-reactance type of head telephone meets this requirement; the low-reactance type does not.

**Ques. 2.311.** What may cause packing of the carbon granules in a carbon button microphone?

*Ans.* Excessive carbon current; jarring with current on.

**Ques. 2.312.** Why should polarity be observed in connecting head telephones directly in the plate circuit of a vacuum tube?

*Ans.* When the head telephones are connected directly in the plate circuit of a vacuum tube, direct current flows through their magnet windings. Unless the direction of this current is correct, this current will serve to demagnetize these magnets and render the head telephones insensitive. On the other hand, if the direction of this current is proper, the magnetic strength of the magnets will be kept up to normal.

**Ques. 2.313.** What precautions should be observed in the use of a double-button carbon microphone?

*Ans.* The current should be balanced in each button and should not exceed 30 milliamperes. The microphone

should not be handled with the current on. The sound level impressed on the diaphragm of the microphone should not be high enough to cause "blasting." Obviously, the microphone should be treated as a sensitive instrument and handled carefully.

**Ques. 2.314.** If low-impedance head telephones of the order of 75 ohms are to be connected to the output of a vacuum-tube amplifier, how may this be done to permit most satisfactory operation?

*Ans.* To do this satisfactorily, an output transformer must be used. The input side of this transformer must have an impedance equal to at least twice the tube's plate resistance. The output must be designed to make the head telephones' load reflect the desired impedance to the tube. This is done by using the proper turns ratio,  $N$ , where  $N = \sqrt{\frac{R_p}{R_L}}$  (approximately), where  $R_p$  = plate resistance, and  $R_L$  = the load resistance.

**Ques. 2.315.** What is the effect on the resonant frequency of adding an inductor in series with an antenna?

*Ans.* This would lower the resonant frequency of the antenna circuit. It would have the same effect as adding physical length to the antenna. The wavelength at which the antenna circuit would resonate would be longer.

**Ques. 2.316.** What is the effect on the resonant frequency of adding a capacitor in series with an antenna?

*Ans.* This would raise the resonant frequency of the antenna circuit. It would have the same effect as shortening the physical length of the antenna. The wavelength at which the antenna circuit would resonate would be shorter.

**Ques. 2.317.** Which type of antenna (Hertz, Marconi, Inverted L, etc.) has the greatest physical length for a given resonant frequency?

*Ans.* The Hertz ungrounded antenna has the greatest physical length for a given frequency.

**Ques. 2.318.** What is the velocity of propagation of radio-frequency waves in space?

*Ans.* Three hundred million meters per second or 186,000 miles per second.

**Ques. 2.319.** What is the relationship between the electrical and physical length of a Hertzian antenna?

*Ans.* A Hertz antenna will radiate a wave equal to approximately twice its physical length.

**Ques. 2.320.** If you desire to operate on a frequency lower than the resonant frequency of an available Marconi antenna, how may this be accomplished?

*Ans.* This may be accomplished by adding an inductance in series with the antenna. This will make the antenna resonant at a lower frequency.

**Ques. 2.321.** What will be the effect upon the resonant frequency if the physical length of a Hertzian antenna is reduced?

*Ans.* The resonant frequency of the antenna will be higher.

**Ques. 2.322.** If the thermocouple of your radiation ammeter burned out and no spare were available, what would you substitute for it, or what methods could be used to determine that the antenna circuit of your transmitter was adjusted to resonance?

*Ans.* If the thermocouple ammeter burned out and no spare was available, a low-voltage bulb, preferably with a carbon filament, or a neon bulb might be connected to a loop of wire several inches in diameter and loosely coupled to the antenna inductor. Maximum brilliance of the lamp would indicate maximum current flow in the antenna circuit. If an

indicating frequency meter is available, the point of resonance adjustment would be indicated by a maximum deflection on the indicating device of the frequency meter if the frequency meter were loosely coupled to the antenna circuit.

**Ques. 2.323.** Which type of antenna has a minimum of directional characteristics in the horizontal plane?

*Ans.* The single radiator vertical antenna.

**Ques. 2.324.** What factors determine the resonant frequency of any particular antenna?

*Ans.* The physical length of the antenna determines the resonant frequency, depending upon the type of antenna used; that is, whether it is grounded or ungrounded. The wavelength of the grounded antenna is approximately 4.2 to 4.5 times its physical length. The Hertz ungrounded antenna has a wavelength of twice its physical length.

**Ques. 2.325.** If the resistance and the current at the base of a Marconi antenna are known, what formula could be used to determine the power in the antenna?

*Ans.* The formula used would be  $I^2R$ , where  $I$  is the current at the base of the antenna, and  $R$  is the radiation resistance.

**Ques. 2.326.** Does the resistance of a copper conductor vary with variations in temperature and if so, in what manner?

*Ans.* The resistance of a copper conductor varies directly with any change in temperature; that is, as the heat increases, the resistance increases and vice versa.

**Ques. 2.327.** What type of insulator is best suited for use as an antenna strain insulator which is exposed to the elements?

*Ans.* Electrical glazed porcelain is best suited for use as an antenna strain insulator.

**Ques. 2.328.** What material is frequently used for relay contacts? Why?

**Ans.** Silver, because it has low resistance, is inexpensive, exhibits a minimum amount of corrosion, and does not pit, easily. Tungsten is also commonly used.

**Ques. 2.329.** Draw a diagram of a simple radio-receiver circuit using a crystal detector for rectification. (See Fig. 2-42.)

**Ans.** See Fig. 2-42.

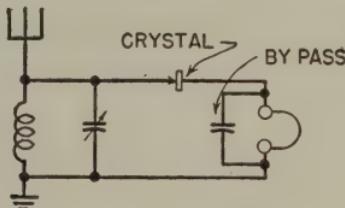


FIG. 2-42.—Simple receiver.

**Ques. 2.330.** Define a "damped wave."

**Ans.** A "damped wave" may be defined as an oscillatory wave train, the energy of which gradually decreases with time until the wave is "damped" out.

**Ques. 2.331.** Why is rosin used as soldering flux in radio construction work?

**Ans.** In soldering, any acid will in time cause corrosion, thus increasing the resistance of electrical connection. This is, of course, understandable. Pure rosin when used as a flux produces no corrosion and is, therefore, used in all high-grade radio work.

**Ques. 2.332.** What is meant by an "harmonic"?

**Ans.** An "harmonic frequency" is a multiple of the fundamental frequency. In radio work, the initial frequency is regarded at the first harmonic, the second multiple of this frequency being the second harmonic, the third multiple the third harmonic, and so forth.

**Ques. 2.333.** What is the function of a no-voltage release winding often incorporated in a direct-current motor starter?

*Ans.* The function of the no-voltage release in a direct-current motor starter is to release the starting handle if the line voltage fails. When the starting handle is released, it flies back from the full-speed running position to the "off" position. This eliminates the possibility of burning out the motor should the line voltage again be applied. Under these conditions, the motor must be restarted by pulling over the starting handle in the regular way.

**Ques. 2.334.** Explain what technique you would employ in giving assistance to a person who was in contact with high voltage.

*Ans.* The important thing in case of accidental electrical shock is to shut off the power immediately or to break contact between the victim and the live conductor. Either one or the other may have to be done first, depending on conditions. In breaking contact between the victim and the live conductor, the rescuer should be careful not to come in contact with the live conductor himself. The conductor or victim might be pushed away from each other by means of a dry stick of wood or other nonconductor.

When the victim is free of the conductor, the treatment would depend on the extent of the shock. If the victim is not unconscious, he should be placed in a reclining position, the head and shoulders being propped up off the floor, and, if possible, a doctor summoned immediately. The victim, if fully conscious, should be given some stimulant, such as one teaspoonful of aromatic spirits of ammonia in a small glass of water, or a hot drink of coffee or tea. He should be kept warm. The victim should be moved as little as possible until he feels able to be moved.

If the victim is unconscious, artificial respiration should be started at once, dressings applied to the burns, and a doctor summoned immediately. On board ship, where no doctor is

available, medical advice may be secured by radio. Keep the victim warm. No liquids should be administered to the victim until he has recovered consciousness. A brief return of natural breathing is not an indication for stopping the resuscitation. The victim must be watched, and if natural breathing stops, artificial respiration should be begun again at once. If it is necessary to change the operator, this change must be made without losing the rhythm of respiration. Artificial respiration should be continued for a period of at least 4 hours, even though the victim may appear to be dead.

**Ques. 2.335.** What are the function and purpose(s) of inter-lock relay switches which are often provided on the access doors of modern radio transmitters?

*Ans.* The function of these relay switches is to cut off all high voltages as soon as the access doors are opened. The purpose of cutting off the voltage is to protect anyone who might enter the transmitter enclosure from coming in contact with live currents with the consequent danger of serious or fatal shock.

**Ques. 2.336.** How may a transmitter or receiver be protected against damage due to high values of induced atmospheric electricity collected by an antenna system?

*Ans.* By the following methods:

1. By grounding the antenna when it is not in use.
2. By the use of a static drain consisting of a high resistance connected between the antenna and the ground.
3. By the use of a lightning arrestor, which, when connected to the antenna and ground, provides an air gap across which the high voltages can jump to ground.

**Ques. 2.337.** Why should all exposed metal parts of a transmitter be grounded?

*Ans.* To protect the operator from coming in contact with a high voltage, thus protecting him against serious or fatal shock. To minimize possible electrostatic coupling.

## ELEMENT 3

### RADIOTELEPHONE

**Ques. 3.01.** In the diagram below:

1. Knowing the impressed voltage  $E$  and the values of the resistors  $R_1$ ,  $R_2$ , and  $R_3$ , explain how you would calculate the currents in each of the resistors.

2. Knowing the value of current in  $R_1$ , and the values of the resistors  $R_1$ ,  $R_2$ , and  $R_3$ , how would you calculate the currents in  $R_2$  and  $R_3$ ? How would you calculate the voltage drop across each of the resistors?

*Ans.* 1. Let  $R_t$  = total resistance, and  $R_x$  = resistance of parallel combination  $R_1$  and  $R_2$ ;

$$R_x = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}, \quad R_t = R_x + R_3.$$

$$\text{Current through } R_3 = \frac{E}{R_t} = I_3.$$

Therefore,

$$I_2 = I_3 \left( \frac{R_1}{R_1 + R_2} \right)$$

and

$$I_1 = I_3 - I_2.$$

2.

$$E_1 = I_1 R_1.$$

$$I_2 = \frac{E_1}{R_2}.$$

$$I_3 = I_1 + I_2.$$

$$E_2 = I_2 R_2.$$

$$E_3 = I_3 R_3.$$

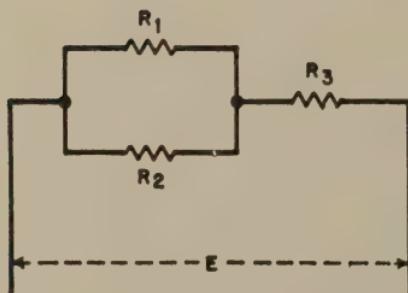


FIG. 3-1.—Resistor network.

**Ques. 3.02.** In the diagram below compute direct-current plate voltage, direct-current grid bias, and supply voltage.

*Ans.* In the diagram below:

1. The direct-current plate voltage will be 75 volts.
2. The direct-current grid bias will be 7.5 volts.
3. The supply voltage will be 82.5 volts.

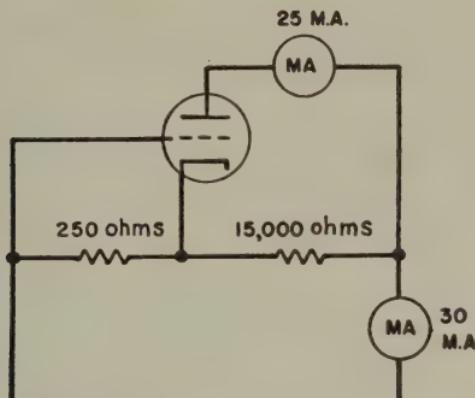


FIG. 3-2.—Voltage divider network.

The computation is as follows:

Plate voltage equals the voltage between the plate and the cathode; if the total current is 30 milliamperes, and if the plate current is 25 milliamperes, then, the current through the 15,000-ohm resistor is 5 milliamperes. Hence, the voltage drop across this resistor is  $0.005 \times 15,000 = 75$  volts.

The total current flows through the 250-ohm resistor. Hence, the voltage drop across this resistor is

$$0.030 \times 250 = 7.5 \text{ volts,}$$

which is the grid-bias voltage. The supply voltage is the sum of these two voltage drops, or 82.5 volts.

**Ques. 3.03.** Define a negatively charged body. A positively charged body.

*Ans.* A negatively charged body is an object containing an excess of electrons. An electron approaching such a body will

be repelled by it. A positively charged body is an object containing a deficiency of electrons. An electron approaching such a body will be attracted to it.

The electric force existing around a positively or negatively charged body extends in all directions. The space in which the charged bodies exert an electric force is called the *electric field*.

**Ques. 3.04.** What are the desirable electrical characteristics of a radio-frequency choke coil?

*Ans.* Low radio-frequency resistance and low distributed capacity are the two most important electrical characteristics of a radio-frequency choke coil. The current-carrying capacity of the choke must also be adequate.

**Ques. 3.05.** Explain the purposes and methods of neutralization in radio-frequency amplifiers.

*Ans.* Neutralization is generally necessary in a radio-frequency amplifier to prevent erratic operation of the circuit which would occur if the amplifier went into self-oscillation owing to feedback. Neutralization compensates feedback.

*Procedure.* Open the plate-supply switch to the radio-frequency stage to be neutralized. Open up the main power switch to all tubes and discharge all high-voltage condensers. Insert a thermocouple galvanometer into the low potential side of the plate tank circuit of the stage to be neutralized. Engage the neutralizing condenser about one-third position. Close the main power switch, but leave the plate-supply switch of the amplifier open. Increase the radio-frequency drive gradually and tune all circuits to resonance. Observe the reading on the thermocouple galvanometer and vary the neutralizing condenser until this reading is a minimum or, preferably, zero. Remove the thermocouple galvanometer and insert the regular ammeter. Close the high-voltage plate-supply switch to the radio-frequency amplifier just neutralized. Carefully recheck and balance all circuits to minimum plate current dips.

**Ques. 3.06.** In a circuit consisting of an inductance having a reactance value of 100 ohms and a resistance of 100 ohms, what will be the phase angle of the current with reference to the voltage?

*Ans.* The phase angle will be 45 degrees, computed as follows:

$$\cos \theta = \frac{R}{Z}; \quad Z = \sqrt{R^2 + X^2}.$$

**Ques. 3.07.** In a circuit consisting of a capacitance having a reactance value of 100 ohms, what will be the phase angle of the current with reference to the voltage?

*Ans.* 90 degrees lead.

**Ques. 3.08.** What is the effective value of a sine wave in relation to its peak value?

*Ans.*

$$\text{Effective value} = \text{Peak value} \times 0.707$$

**Ques. 3.09.** What is the meaning of "phase difference"?

*Ans.* "Phase difference" is a measure in electrical degrees of the separation between similar relative values of current and voltage in an alternating-current circuit, or of either of these two relative quantities in relation to the other in two or more circuits, the quantities all having the same frequency. Phase difference is expressed as an angle of lag or lead.

**Ques. 3.10.** What factors must be known in order to determine the power factor of an alternating-current circuit?

*Ans.* The true watts, as indicated by a wattmeter, and the volts and amperes in the circuit, as indicated by a voltmeter and ammeter. The formula for power factor can then be expressed:

$$\text{Power factor} = \frac{W}{EI}; \frac{R}{Z}; \cos \theta$$

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 3.11.** What is the product of the readings of a voltmeter and ammeter in an alternating-current circuit?

*Ans.* Apparent power in volt-amperes is the product of the readings of a voltmeter and ammeter in an alternating-current circuit.

**Ques. 3.12.** In what units is the power output of an alternator (alternating current generator) usually expressed?

*Ans.* Preferably in volt-amperes; but manufacturers invariably rate output in watts as almost any radio manufacturer's instruction book will show.

**Ques. 3.13.** What are the properties of a series condenser, acting alone in an alternating-current circuit?

*Ans.* A series condenser acting alone in an alternating-current circuit will cause the current to lead the voltage by 90 degrees. The reactance of the condenser will vary inversely as the frequency varies.

**Ques. 3.14.** If the value of inductance in a purely inductive circuit is doubled, what is the effect upon the phase angle?

*Ans.* No effect; the phase angle is still a 90-degree lag.

**Ques. 3.15.** What is the reactance value of a condenser of 0.005 microfarad at a frequency of 1,000 kilocycles?

*Ans.* The reactance value is 31.8 ohms, computed:

$$X_c = 10^6 / 2\pi fC.$$

**Ques. 3.16.** State the mathematical formula for the energy stored in the magnetic field surrounding an inductance carrying an electric current.

*Ans.*

$$W = \frac{1}{2}LI^2 \text{ joules,}$$

where  $L$  = henrys.

$I$  = amperes.

**Ques. 3.17.** What is the current and voltage relationship when inductive reactance predominates in an alternating-current circuit?

*Ans.* When an inductive reactance predominates in an alternating-current circuit, the current lags the voltage.

**Ques. 3.18.** Given a series circuit consisting of a resistance of 4 ohms, an inductive reactance of 4 ohms, and a capacitative reactance of 1 ohm; the applied circuit alternating e.m.f. is 50 volts. What is the voltage drop across the inductance?

*Ans.* The voltage drop is 40 volts, computed as follows:

$$E_L = IX_L, \quad I = \frac{E}{Z}, \quad Z = \sqrt{R^2 + X^2}, \\ X = X_L - X_C.$$

**Ques. 3.19.** What would be the effect if direct current were applied to the primary of an alternating-current transformer?

*Ans.* The current in the primary would be limited only by the direct-current resistance of the circuit. Unless the applied voltage was very small, the current would either blow the fuses or burn out the transformer in a few seconds. To guard against this and other overload possibilities, fuses should always be in the feed line to a transformer.

**Ques. 3.20.** If a power transformer having a voltage step-up ratio of one to five is placed under load, what will be the approximate ratio of primary to secondary current?

*Ans.* Five to one.

**Ques. 3.21.** What factor(s) determine the voltage ratio of a power transformer?

*Ans.* Turns ratio.

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 3.22.** Define "eddy currents."

*Ans.* "Eddy currents" may be defined as losses set up in the core material by induction and manifested as heat.

**Ques. 3.23.** What is the meaning of "skin effect" in conductors of radio-frequency energy?

*Ans.* The tendency of high-frequency currents to travel on the surface of a conductor is known as "skin effect." This effect is caused by the varying density of the electric field in the conductor, which acts to produce the lowest reactance path on the surface of the conductor.

**Ques. 3.24.** Neglecting distributed capacitance, what is the reactance of a 5-millihenry choke coil at a frequency of 1,000 kilocycles?

*Ans.* The reactance is 31,400 ohms, computed according to the formula  $X_L = 2\pi fL$ .

**Ques. 3.25.** What is meant by the term "radiation resistance"?

*Ans.* The term "radiation resistance" is that value of resistance which, when inserted in series with the antenna at the point of maximum current, will consume the same amount of power as is actually radiated.

**Ques. 3.26.** What is the value of total reactance in a series resonant circuit at the resonant frequency?

*Ans.* The total reactance in a series resonant circuit at the resonant frequency is zero.

**Ques. 3.27.** Should the number of turns of an inductance be increased or decreased in order to raise the resonant frequency?

*Ans.* To increase the frequency, the number of turns of an inductance should be decreased.

**Ques. 3.28.** What is the value of reactance across the terminals of the capacitor of a parallel resonant circuit, at the resonant frequency, and assuming zero resistance in both legs of the circuit?

*Ans.* The reactance is zero; the impedance is infinite.

**Ques. 3.29.** Given a series resonant circuit consisting of a resistance of 6.5 ohms, and equal inductive and capacitative reactances of 175 ohms, what is the voltage drop across the resistance, assuming the applied circuit potential is 260 volts?

*Ans.* Inasmuch as we have equal inductive and capacitative reactances, we have resonance. At the resonant frequency, the voltage drop across a series resonant circuit is zero. Hence, the full voltage would be applied across the resistor. Therefore, the voltage drop across the resistance would be 260 volts.

**Ques. 3.30.** Given a series resonant circuit consisting of a resistance of 6.5 ohms, and equal inductive and capacitative reactances of 175 ohms, what is the voltage drop across the inductance when the applied circuit potential is 260 volts?

*Ans.*  $E_L = IX_L = 40 \times 175 = 7,000$  volts.

**Ques. 3.31.** Under what conditions will the voltage drop across a parallel-tuned circuit be a maximum?

*Ans.* At resonance, when  $X_L = X_C$  and ohmic resistance is small (when the admittances of the two branches are equal).

**Ques. 3.32.** How may the resonant frequency of an antenna circuit be increased?

*Ans.* The resonant frequency of a Hertz ungrounded antenna may be increased by shortening the physical length of the antenna.

The resonant frequency of the Marconi or grounded type of antenna may be increased by connecting a condenser in series with the antenna.

**Ques. 3.33.** Draw a simple schematic diagram showing a method of coupling a modulator tube to a radio-frequency power-amplifier tube to produce plate modulation of the amplified radio-frequency energy.

*Ans.* See Fig. 3-3.

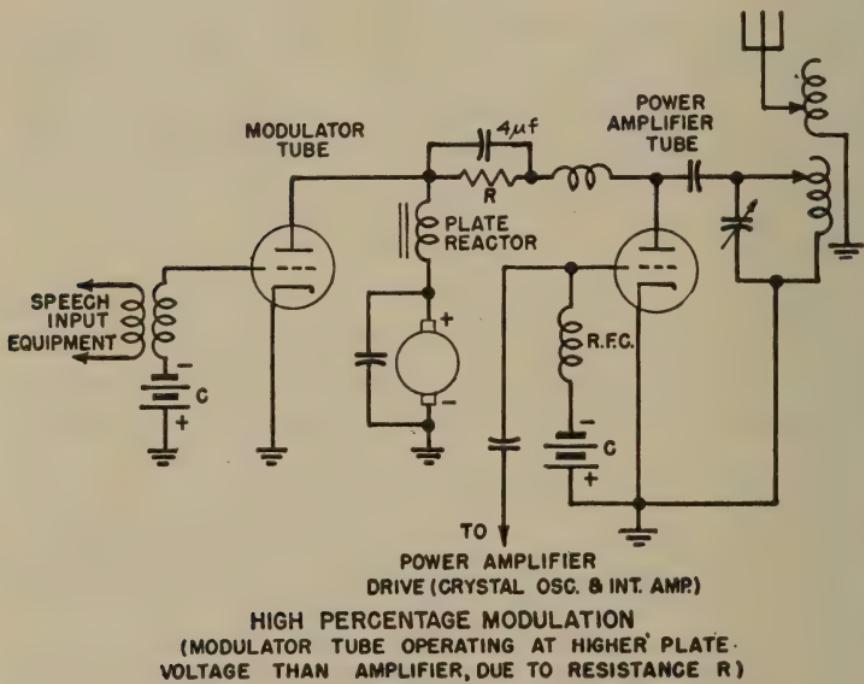


FIG. 3-3.—Plate-modulation system.

**Ques. 3.34.** Draw a diagram of a carrier-wave envelope when modulated 50 per cent by a sinusoidal wave. Indicate

on the diagram the dimensions from which the percentage of modulation is determined.

Ans. See Fig. 3-4.

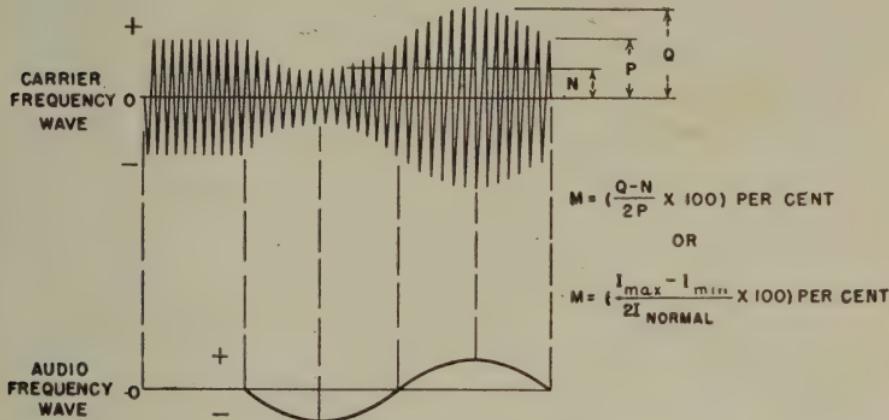


FIG. 3-4.—Carrier-wave envelope.

Ques. 3.35. Draw a diagram of a condenser microphone circuit complete with two stages of audio amplification.

Ans. See Fig. 3-5.

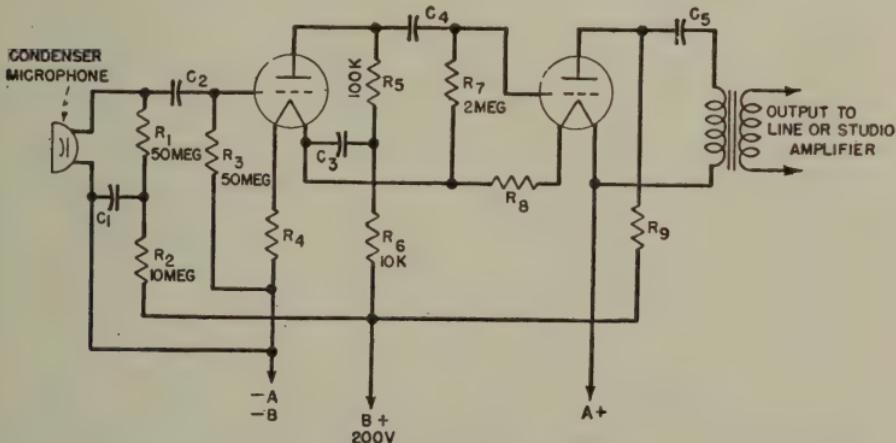


FIG. 3-5.—Microphone amplifier.

Ques. 3.36. Draw a simple schematic diagram showing a Heising modulation system capable of producing 100 per

cent modulation. Indicate power-supply polarity where necessary.

Ans. See Fig. 3-3.

Ques. 3.37. Draw a simple schematic diagram showing a method of suppressor-grid modulation of a pentode-type vacuum tube.

Ans. See Fig. 3-6.

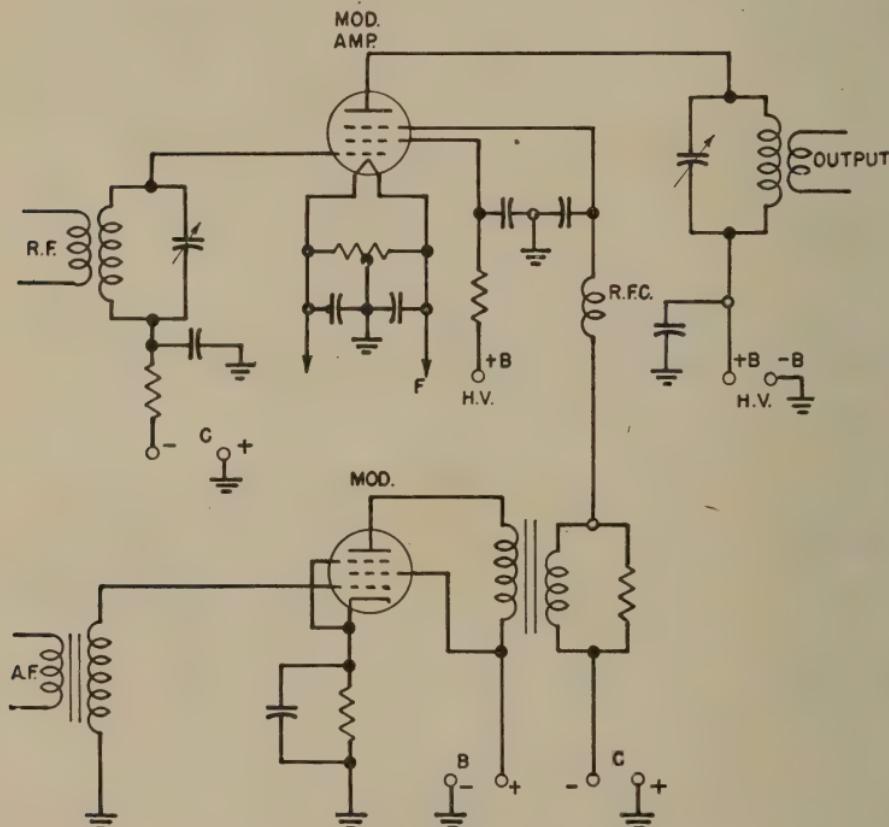


FIG. 3-6.—Suppressor-grid-modulation system.

Ques. 3.38. Draw a simple schematic diagram showing a method of coupling a modulator tube to a radio-frequency power-amplifier tube to produce grid modulation of the amplified radio-frequency energy.

*Ans.* See Fig. 3-7.

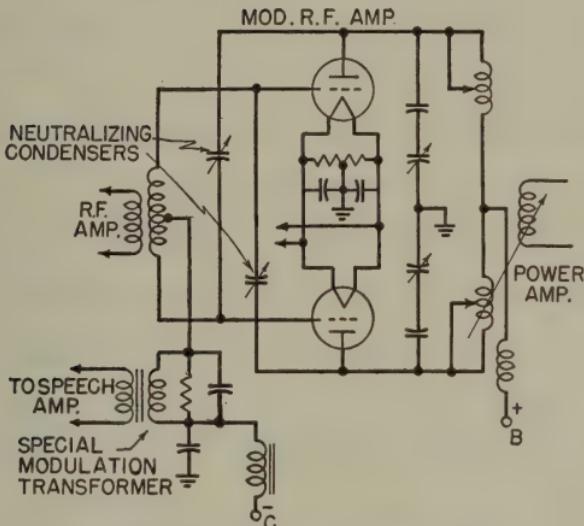


FIG. 3-7.—Grid-modulation system.

**Ques. 3.39.** What is meant by "frequency shift" or "dynamic instability" with reference to a modulated radio-frequency emission?

*Ans.* "Frequency shift" or "dynamic instability" is that condition in modulated amplifiers in which the rapid variations of the carrier frequency in both frequency and amplitude produce heavy load changes. If these load changes are not properly accommodated by the power-supply system, oscillatory circuit constants, tube constants, a frequency shift will occur. Frequency shift due to unstable conditions manifests itself by broad tuning response at the receiving end.

**Ques. 3.40.** In radiotelephony, what is meant by "the process by which the amplitude of the carrier wave is varied in accordance with the speech or other signal to be transmitted"?

*Ans.* *Amplitude modulation* means the process of varying the amplitude of the carrier frequency to make its envelope

## *RADIO OPERATING QUESTIONS AND ANSWERS*

conform to the audio intelligence frequencies impressed on the transmitter by the speech input equipment. This is in contrast to frequency modulation in which system the frequency of the carrier is varied or modulated for the same purpose.

**Ques. 3.41. What is meant by "high-level" modulation?**

*Ans.* "High-level" modulation is modulation produced in the last radio-frequency stage of the transmitter.

**Ques. 3.42. What is meant by "grid modulation"?**

*Ans.* By "grid modulation" is meant modulation produced by the introduction of the modulating wave into any of the grid circuits of any tube in which the carrier-frequency wave is present.

**Ques. 3.43. Define "plate modulation."**

*Ans.* "Plate modulation" is modulation produced by the introduction of the modulating wave into the plate circuit of any tube in which the carrier-frequency wave is present.

**Ques. 3.44. Describe the construction and characteristics of a dynamic-type microphone.**

*Ans.* The dynamic microphone consists of a moving coil mounted between the poles of a powerful permanent magnet, the construction of which is similar to a dynamic speaker. The microphone can stand very rough usage and can be handled while in operation if care is taken not to handle it too roughly. The output level is approximately -85 db. The frequency response is excellent over a range of from 60 to 10,000 cycles. This microphone is substantially nondirectional, but for angles greater than 90 degrees off the axis the high-frequency response falls off rapidly.

**Ques. 3.45. Describe the construction and characteristics of a ribbon-type microphone.**

*Ans.* The ribbon or velocity microphone consists of a very thin ribbon of corrugated aluminum, which is loosely suspended between the poles of a powerful magnet. The position of the ribbon is such that the magnetic field cuts the edges of the ribbon, leaving the ribbon free to move between the poles of the magnet without touching them. Sound waves deflect the ribbon causing it to cut the magnetic flux of the magnet and generate an e.m.f. proportional to the velocity of the sound waves impressed upon it. The ribbon microphone may be used to pick up sound from either front or back, but the response drops off rapidly as the source of the sound moves off the axis. The output level of the ribbon microphone is approximately -100 db. Its frequency response is excellent from approximately 20 to 15,000 cycles per second.

**Ques. 3.46. Describe the construction and characteristics of a condenser-type microphone.**

*Ans.* The condenser microphone consists of a tightly stretched diaphragm which acts as one plate of the condenser. This plate, when varied in relative position to another plate placed in back of the diaphragm by the movement of the sound wave, varies the capacitance of the condenser and the e.m.f. across its output terminals. This change in e.m.f. produces a variable drop across a resistance, which is in series with the condenser and the charging source. Hence, the output wave form conforms to the impressed audio wave form. The output of the condenser microphone is approximately -95 db. Owing to the high output resistance of this microphone, it is necessary that the output leads be very short. The condenser microphone unit usually includes a two-stage audio pre-amplifier. The frequency response of the condenser microphone is excellent from approximately 30 to 9,000 cycles per second.

**Ques. 3.47. What is meant by "low-level" modulation?**

## *RADIO OPERATING QUESTIONS AND ANSWERS*

*Ans.* "Low-level" modulation is modulation produced in a radio-frequency stage preceding the final radio-frequency stage.

**Ques. 3.48.** Which type of commonly used microphone has the greatest sensitivity?

*Ans.* Carbon microphone.

**Ques. 3.49.** Describe the construction and characteristics of a crystal-type microphone.

*Ans.* The crystal microphone employs a piezoelectric crystal as its actuating unit, which is coupled to the diaphragm through a lever arrangement. The conventional crystal microphone is made up of several crystal cells arranged so that each cell aids the others to increase the over-all sensitivity. The microphone is affected very little by temperature changes. The output is approximately -85 db. Owing to the high impedance of the crystal, the output may be worked directly into the grid of the amplifier tube. The frequency response is excellent over the whole audio spectrum.

**Ques. 3.50.** Describe the construction and characteristics of a carbon-button type microphone.

*Ans.* A single-button carbon microphone consists of a tightly stretched diaphragm fixed in front of a metal cup filled with carbon granules, the cup assembly being called a "button." The natural frequency of the diaphragm is well above 5,000. The diaphragm is damped by an air cushion to improve its frequency response, which extends approximately from 60 to 5,000 cycles. A hiss is noticeable unless the sound level is high. This is the most sensitive microphone.

**Ques. 3.51.** What is a "velocity" type microphone?

*Ans.* A velocity microphone is one which generates an e.m.f. proportional to the velocity of the sound wave impressed upon it. (See Ques. 3.45.)

**Ques. 3.52.** What might be the cause of variations in plate current of a class B type of modulator?

*Ans.* Under normal conditions with complex modulation the plate current of a class B modulator is constantly varying, depending upon the amplitude of the speech input wave.

**Ques. 3.53.** What is the relationship between the average power output of the modulator and the modulated-amplifier plate-circuit input, under 100 per cent, sinusoidal plate modulation?

*Ans.* The correct ratio of the average power output of the modulator to the direct-current power input to the modulated amplifier is 50 per cent.

**Ques. 3.54.** What would be the effect of a shorted turn in a class B modulation transformer? In a class A modulation transformer?

*Ans.* In a class B modulation transformer the tube connected to the side of the transformer containing the shorted turn would be rendered inoperative because that section of the transformer would probably burn out. Severe distortion.

In a class A modulation transformer a shorted turn would probably cause the transformer to burn out, rendering the entire amplifier inoperative. Severe distortion.

**Ques. 3.55.** Why is a high percentage of modulation desirable?

*Ans.* Because it results in increased plate efficiency of the amplifier handling the modulated carrier and permits the greatest possible radiated power. It also gives a greater ratio of useful power in the receiving system and less interference between stations on adjacent channels.

**Ques. 3.56.** What are some of the possible results of overmodulation?

## *RADIO OPERATING QUESTIONS AND ANSWERS*

*Ans.* Overmodulation results in a widening of the frequency band causing interference on adjacent channels. Overmodulation also causes distortion in the audio components of the radiated wave. Since the continuity of the carrier is interrupted, it means that there are harmonics radiated and that the transmission occupies a band which is wider than necessary, causing interference on adjacent channels.

**Ques. 3.57. What might cause frequency modulation in an amplitude modulated radiotelephone transmitter?**

*Ans.* Excessive tube or circuit load changes.

**Ques. 3.58. What percentage of antenna-current increase should be expected between unmodulated Conditions and 100 per cent sinusoidal modulation?**

*Ans.* The antenna current will rise approximately 22.5 per cent if the modulating wave has a sinusoidal characteristic. In practical broadcasting, owing to the unsymmetrical nature of the modulated wave, this increase in antenna current cannot be depended upon to indicate 100 per cent modulation.

**Ques. 3.59. Under 100 per cent modulation conditions, what is the ratio of instantaneous peak antenna current to unmodulated antenna current?**

*Ans.* Two. At 100 per cent modulation the peak value of the carrier current rises to twice the unmodulated peak value.

**Ques. 3.60. Under 100 per cent modulation conditions, what is the ratio of instantaneous peak antenna power to unmodulated antenna power?**

*Ans.* Four. At 100 per cent modulation the peak power is four times the carrier power.

**Ques. 3.61. What might be the cause of a decrease in antenna current of a high-level amplitude modulated radiotelephone transmitter, when modulation is applied?**

*Ans.* A downward fluctuation of a high-level modulated telephone transmitter might be caused by any of the following reasons:

1. Poor tubes.
2. Improper operating voltages.
3. Defective speech input.
4. Improper neutralization.
5. Low filament voltage.
6. Defective filter condensers in power supply.
7. Momentary oscillator failure.
8. Improperly tuned antenna circuit.
9. Open transmission line.
10. Overmodulation in grid modulation system.

**Ques. 3.62.** How should a regenerative receiver be adjusted for optimum response to a weak unmodulated carrier?

*Ans.* The following steps are necessary:

1. Start the detector oscillating.
2. Tighten coupling between tuned circuits.
3. Carefully tune circuits to desired signal frequency
4. Reduce feedback to a point just above the point where the detector stops oscillating.

**Ques. 3.63.** If a regenerative receiver oscillates too freely with minimum tickler coupling, what adjustment would reduce the feedback?

*Ans.* A reduction in plate or filament potential.

**Ques. 3.64.** Why is it necessary to use an oscillating detector for reception of an unmodulated carrier?

*Ans.* With an unmodulated carrier (*CW*) there are no pulses of current for the detector to act upon. It is necessary, therefore, to provide some other means to secure the audio component. This is done by arranging to modulate the signal voltage at the receiver; and this is the function of the oscil-

lating detector (autodyne), which heterodynes or beats with the received signal voltage. This action sets up a "difference frequency" which is in the audio range, and which serves to provide the necessary audio components.

**Ques. 3.65. What is the purpose of shielding in a multistage radio receiver?**

*Ans.* The purpose of shielding in a multistage radio receiver is to prevent electrical interaction between the various receiver components, which interaction would disturb their normal operation. Shielding prevents the lines of force surrounding the shielded component from leaving the area within the shield. Shielding also prevents any outside lines of force from entering the shielded compartment.

**Ques. 3.66. Explain what circuit conditions are necessary in a regenerative receiver for maximum response to a modulated signal.**

*Ans.* Regeneration must be increased up to the point just below that at which oscillation begins. The detector must not oscillate, but be almost ready to do so.

**Ques. 3.67. What feedback conditions must be satisfied in a regenerative detector for most stable operation of the detector circuit in an oscillating condition?**

*Ans.* The negative resistance provided by the feedback arrangement must neutralize the positive resistance of the detector circuit to the extent that the circuit oscillates. The feedback must be adjusted so that the circuit does not stop, or tend to stop, oscillating. This adjustment is definitely into the oscillating region of the dial-control setting, and is best found by experiment.

**Ques. 3.68. What are the advantages to be obtained from adding a tuned radio-frequency amplifier stage ahead of the first detector (converter) stage of a superheterodyne receiver?**

*Ans.* An added stage of tuned radio-frequency amplification ahead of the first detector in a superheterodyne receiver will tend to eliminate image frequencies, thus increasing selectivity and improving sensitivity.

Radio-frequency amplification ahead of the mixer or converter stage is always desirable so that receiver hiss may be reduced to values determined by "first-circuit noise."

**Ques. 3.69.** What feedback conditions must be satisfied in a regenerative detector in order to obtain sustained oscillations?

*Ans.* The positive resistance of the detector circuit must be completely neutralized by the negative resistance provided by the feedback voltage.

**Ques. 3.70.** How is automatic volume control accomplished in a radio receiver?

*Ans.* Automatic volume control is accomplished in some circuits by rectifying a part of the radio-frequency energy fed to the second detector and sending this energy to ground through a resistor. The voltage drop in the resistor is then taken off and used to negatively bias the grids of the radio-frequency stages. This reduces the gain in these tubes in inverse proportion to the amount of energy fed to the second detector. Therefore, the overall output to the receiver is maintained at a predetermined level.

**Ques. 3.71.** If a superheterodyne receiver is tuned to a desired signal at 1,000 kilocycles, and its conversion oscillator is operating at 1,300 kilocycles, what would be the frequency of an incoming signal which would possibly cause "image" reception?

*Ans.* It is evident that the intermediate frequency is 300 kilocycles. Hence, a frequency of 1,600 kilocycles, reaching the grid of the converter tube will produce an intermediate frequency of 300 kilocycles if the conversion oscillator is tuned

to 1,300 kilocycles. Hence, 1,600 kilocycles is the *image*.

**Ques. 3.72.** If a tube in the only radio-frequency stage of your receiver burned out, how could temporary repairs or modifications be made to permit operation of the receiver if no spare tube is available?

**Ans.** The antenna could be connected to the control grid of the succeeding tube through a small condenser. However, the degree of satisfaction to which such an arrangement would operate would depend entirely upon the circuit connections employed in the receiver.

**Ques. 3.73.** What are the characteristics of plate detection?

**Ans.** Linear output with strong signal is the chief characteristic of plate detection. Under these conditions, minimum distortion occurs.

**Ques. 3.74.** What is the purpose of a radio-frequency choke?

**Ans.** To keep radio-frequency voltages out of the direct-current supply circuit is the most general use of the radio-frequency choke. However, a radio-frequency choke would be useful in any circuit where it is desired to prevent the passage of radio-frequency currents.

**Ques. 3.75.** What would be the effect upon a radio receiver if the vacuum-tube plate potential were reversed in polarity?

**Ans.** The receiver would not operate.

**Ques. 3.76.** What would be the effect upon the operation of a receiver if the grid return is connected to the positive rather than the negative terminal of the filament battery?

**Ans.** In all modern circuits, the grid return is connected to the cathode, or negative, side of the filament. A connec-

tion to the positive side of the filament might cause an excessive grid-current flow, resulting in distortion of the output signal. Under these conditions, losses would occur in the signal output owing to the canceling effect of the grid current on the grid input voltage. This would result in a weakened plate output.

**Ques. 3.77.** Draw a simple schematic diagram of a system of coupling a single electron tube employed as a radio-frequency amplifier to a Hertz-type antenna.

**Ans.** See Fig. 3-8.

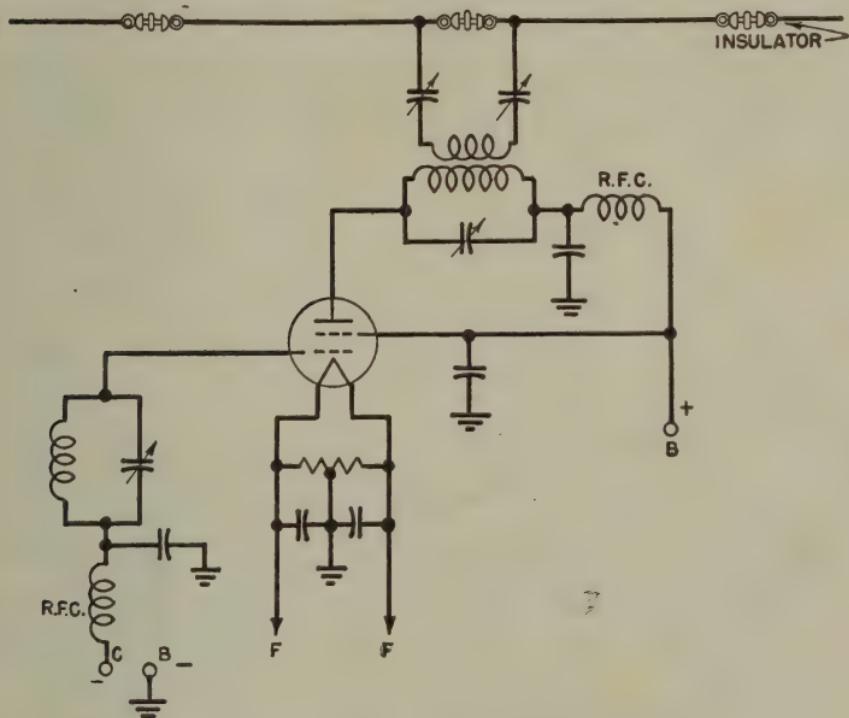


FIG. 3-8.—Hertz-radiator coupling system.

**Ques. 3.78.** Draw a simple schematic diagram indicating a link coupling system between a tuned-grid tuned-plate oscillator stage and a single electron tube, neutralized amplifier.

RADIO OPERATING QUESTIONS AND ANSWERS

Ans. See Fig. 3-9.

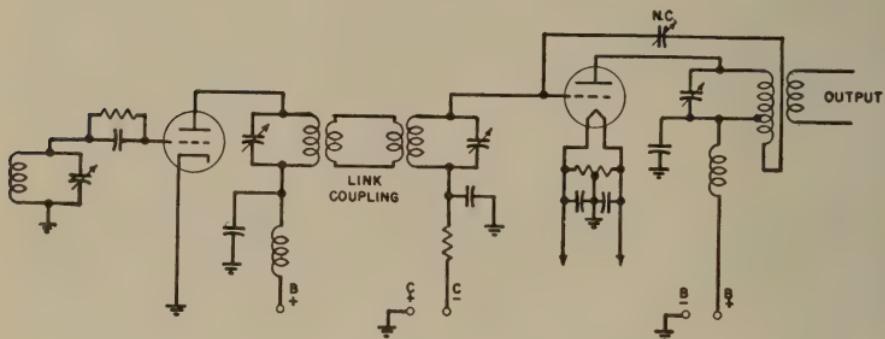


FIG. 3-9.—Link coupling arrangement.

Ques. 3.79. Draw a simple schematic diagram of a push-pull, neutralized radio-frequency amplifier stage, coupled to a Marconi-type antenna system.

Ans. See Fig. 3-10.

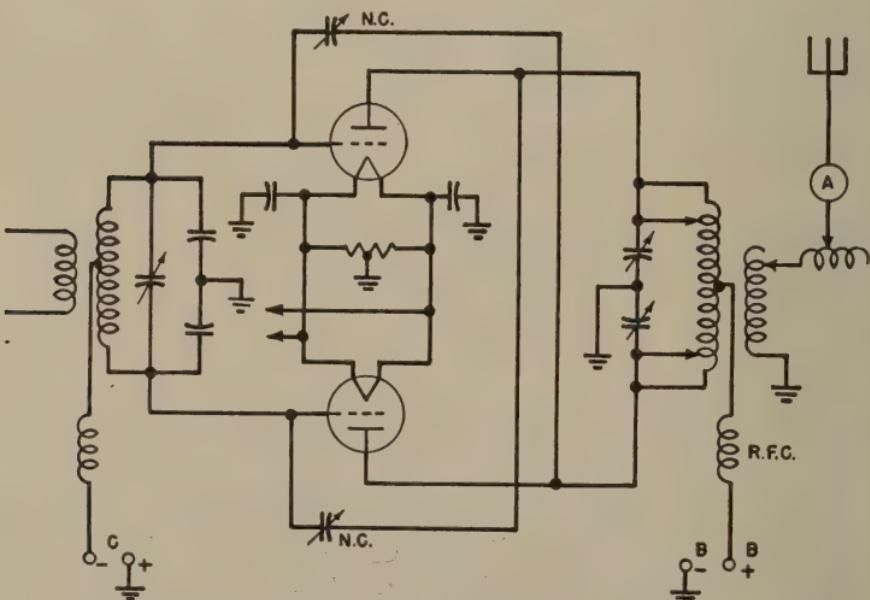


FIG. 3-10.—Push-pull neutralized radio-frequency amplifier.

**Ques. 3.80.** Draw a simple schematic diagram of a system of neutralizing the grid-plate capacitance of a single electron tube employed as a radio-frequency amplifier.

*Ans.* See Fig. 3-9.

**Ques. 3.81.** Draw a simple schematic diagram showing the proper method of obtaining direct-current screen-grid voltage from the plate supply in the case of a plate-modulated pentode, class C amplifier.

*Ans.* See Fig. 3-11.

**Ques. 3.82.** What is the purpose of a buffer amplifier?

*Ans.* The purpose of the buffer amplifier is to isolate the oscillator from the succeeding stages of radio-frequency amplification. This prevents any reaction between the modulated radio-frequency amplifiers and the oscillator which might cause frequency instability.

**Ques. 3.83.** What is a "frequency doubler" stage?

*Ans.* A "frequency doubler" stage is a radio-frequency amplifier, the output frequency of which is double that of the input frequency. A frequency doubler is used in connection with a crystal oscillator when the desired output frequency exceeds the safe operating limits of the crystal.

**Ques. 3.84.** What are the advantages of a master-oscillator power-amplifier type of transmitter as compared to a simple oscillator transmitter?

*Ans.* The chief advantage of a master-oscillator power-amplifier type of transmitter is that it has a greater frequency stability than the simple oscillator transmitter. This stability is achieved by isolating the oscillator from the antenna circuit by a radio-frequency amplifier, thus preventing any capacity changes in the antenna from affecting the frequency of the oscillator. Capacity changes in the antenna circuit are

especially likely to occur on shipboard where the effective height of the antenna is changed by the movement of the ship in the sea.

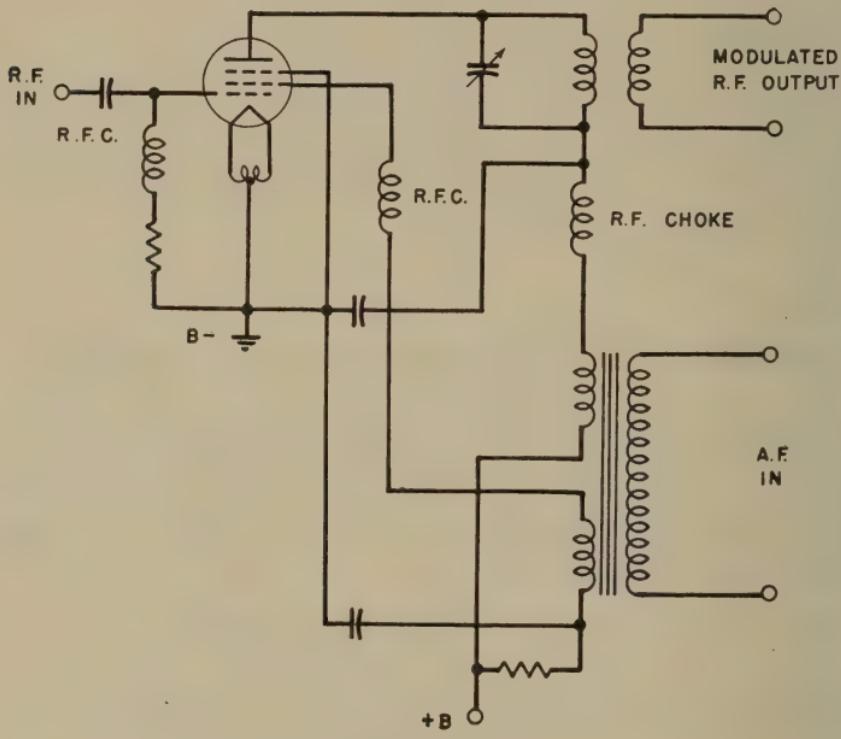


FIG. 3-11.

**Ques. 3.85. What are the differences between Colpitts and Hartley oscillators?**

**Ans.** In the Colpitts oscillator the grid circuit receives its excitation from a split tank condenser. In the Hartley oscillator, the grid receives its excitation from a split tank inductance. Otherwise, operation of both oscillators is the same.

**Ques. 3.86. What is the primary purpose of a grid leak in a vacuum-tube transmitter?**

**Ans.** A grid leak is used primarily to develop operating bias. It also serves to maintain a constant load on an amplifier

to minimize distortion when the grid of the succeeding stage is driven positive.

**Ques. 3.87.** By what means is feedback coupling obtained in a tuned-grid tuned-plate type of oscillator?

*Ans.* Through the grid-to-plate capacity of the tube.

**Ques. 3.88.** What may be the result of parasitic oscillations?

*Ans.* Parasitic oscillations cause a general reduction in the overall efficiency of the transmitter. Depending upon the type of parasitic oscillations present, they may cause erratic operation of the various radio-frequency circuits and have a modulating effect on the carrier frequency. They also may cause serious plate overheating.

**Ques. 3.89.** How may the production of harmonic energy by a vacuum-tube radio-frequency amplifier be minimized?

*Ans.* The following methods may be used to minimize the production of harmonic energy:

1. Push-pull circuits with matched tubes.
2. Inductive coupling to the load.
3. Use of a Faraday screen.
4. Use of link coupling with one side grounded.
5. Use of an additional shunt tank for coupling purposes.
6. Proper neutralization.
7. Optimum ratio of volt-amperes to watts in the tank.
8. Use of two-element low-pass filter.

**Ques. 3.90.** What is a definition of "parasitic oscillations"?

*Ans.* "Parasitic oscillations" may be defined as very undesirable oscillations generated in a tube transmitter owing to the formation of oscillatory circuits by the inductance and capacity, either lumped or distributed, in the circuit. Parasitic oscillations may occur at audio or radio frequencies.

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 3.91.** What is the purpose of a Faraday screen between the final tank inductance of a transmitter and the antenna inductance?

*Ans.* The purpose of a Faraday screen is to minimize the radiation of harmonic frequencies. This it does by reducing the capacitive coupling between the amplifier and antenna circuits, by which the harmonics are chiefly transmitted.

**Ques. 3.92.** How may the distortion effects caused by class B operation of a radio-frequency amplifier be minimized?

*Ans.* Distortion effects in a class B radio-frequency amplifier may be minimized by:

1. Push-pull operation.
2. Matched tubes.
3. High *Q* tank circuit.
4. Correct operating bias.
5. Signal amplitude limited to linear range.

**Ques. 3.93.** What is the effect of carrier shift in a plate modulated class C amplifier?

*Ans.* Carrier shift causes unwanted harmonics and additional side-band frequencies, resulting in interference with other stations on adjacent frequencies. (See Ques. 6.42.)

**Ques. 3.94.** What are some possible indications of a defective transmitting vacuum tube?

*Ans.* Some possible indications of a defective transmitting vacuum tube are:

1. Burned-out filament (dark tube).
2. Low emission as indicated by no reading, or a low reading, on the plate-current meter accompanied by a slightly high voltage reading.
3. A gassy tube, as indicated by a blue haze, red-hot plate, and/or fluctuations in plate current, or by excessive grid-current flow.

**Ques. 3.95.** What would be possible indications that a vacuum tube in a transmitter has subnormal filament emission?

*Ans.* Some possible indications of subnormal filament emission are:

1. No oscillation by oscillator.
2. Lowered radiation.
3. Lowered plate current in the amplifier containing the subnormal tube.

**Ques. 3.96.** What are possible causes of negative carrier shift in a linear radio-frequency amplifier?

*Ans.* Some possible causes of negative carrier shift are:

1. Overmodulation in a grid-modulated amplifier.
2. Modulator tube(s) not matched to modulated tube(s), when plate modulation is used.
3. Excessive radio-frequency excitation of modulated tube(s).
4. Insufficient by-pass on cathode resistor of modulated tube(s).
5. Insufficient grid bias on amplifier tube(s). (See Ques. 6.42.)

**Ques. 3.97.** In a modulated class C radio-frequency amplifier, what is the effect of insufficient excitation?

*Ans.* If the radio-frequency excitation is low, low efficiency will result because the carrier cannot follow the positive audio-frequency peaks, resulting in distortion and carrier shift.

**Ques. 3.98.** What is the purpose of a dummy antenna?

*Ans.* A dummy antenna is used to load a transmitter for testing purposes without radiation. The dummy antenna may consist of a bank of lamps, or other equal resistors. The resistance of the dummy antenna must be equivalent to that of the working antenna.

**Ques. 3.99.** In a class C radio-frequency amplifier stage of a transmitter, if plate current continued to flow and radio-

frequency energy is still present in the antenna circuit, what defect would be indicated?

*Ans.* On a radiotelegraph transmitter, this would indicate defective keying, usually a failure of the keying bias to block the tubes when the key is up or that keying relay is closed.

In a radiotelephone transmitter, fitted with a press-to-talk button, a continuous flow of plate current would indicate a defective cut-off bias supply or circuit.

**Ques. 3.100.** If the transmitter filament voltmeter should cease to operate, how may the approximately correct filament rheostat adjustment be found?

*Ans.* By observing the color of the filaments and by noting other meter readings to see that they are normal.

**Ques. 3.101.** What are some possible causes of overheating vacuum-tube plates?

*Ans.* Vacuum-tube plates may be caused to be overheated by any of the following:

1. Plate tank circuit out of tune.
2. Improper grid bias.
3. Gassy tube.
4. Improper neutralization.
5. Improper operating voltages.
6. Defective tube(s), not necessarily gassy.

**Ques. 3.102.** Should the plate current of a modulated class C amplifier stage vary or remain constant under modulation conditions? Why?

*Ans.* The plate current of a plate-modulated class C amplifier stage remain constant under modulation conditions even up to 100 per cent modulation. The reason for this constant current is that the average value of the direct-current component will be zero owing to the equality of the rise and fall during the audio-frequency cycle. In other words, the

current *tends* to rise on the positive half of the audio-frequency cycle and *tends* to decrease on the negative half of the cycle, thereby making the average *change* zero. Thus, the plate current remains steady during modulation.

**Ques. 3.103.** What is the effect of a swinging antenna upon the output of a simple oscillator?

*Ans.* Inasmuch as the antenna circuit is coupled directly to the plate circuit of a simple oscillator, any variation in antenna capacity, such as might be caused by a swinging antenna, would be reflected into the tube's plate circuit. This action would be equivalent to placing a fluctuating load on the oscillator and would result in frequency instability.

**Ques. 3.104.** What factors permit high conduction currents in a hot-cathode type of mercury-vapor rectifier tube?

*Ans.* High conduction currents in a hot-cathode type of mercury-vapor rectifier tube are permissible because the current is carried chiefly by ions in the tube rather than by electrons emitted from the cathode. The low (15-volt) voltage drop across the tube while conducting makes the plate power dissipation ( $EI$ ) low even for large values of plate current.

**Ques. 3.105.** List the principal advantages of a mercury-vapor rectifier over a high-vacuum-tube type of rectifier.

*Ans.* The principal advantages of the mercury-vapor rectifier over a high-vacuum-tube type of rectifier are its better voltage regulation and higher operating efficiency. In comparing the efficiency of the high-vacuum-tube type with that of the mercury-vapor type, it has been found that the latter may be approximately 99 per cent efficient as compared with approximately 87 per cent of the former.

**Ques. 3.106.** What is the effect, upon the voltage regulation of a rectifier and filter system, of the resistance of the filter chokes?

*Ans.* The less resistance in the filter chokes, the better will be the regulation.

**Ques. 3.107.** Describe the theory of current conduction and rectification by means of cold-cathode, gassy-diode vacuum tubes.

*Ans.* When an alternating difference of potential is applied across the electrodes, one of which is a cold cathode and the other a rod-shaped anode, the strain exerted upon the gaseous atmosphere will result in the breakdown of the gas atoms, (ionization due to collision). If the electrodes are identical in construction an electron current will flow in both directions under conditions of ionization. However, in order that unilateral flow only shall take place under application of an alternating voltage, the plates are of different design with regard to each other. This special design permits electrons to flow from one element to the other when the gas ionizes but not in the reverse direction. This action permits the use of this type of tube for rectification purposes.

**Ques. 3.108.** Describe the principle of operation of a synchronous type of mechanical rectifier.

*Ans.* There are two general types of mechanical rectifiers, namely, the vibrating-reed and the synchronous-commutator types. The vibrating-reed rectifier consists of a metal strip or reed in which the reed forms the armature of an electromagnet excited from the alternating-current supply. The reed is arranged with contacts which are opened and closed periodically with the change of the alternating-current cycle. If one pair of contacts are used, the circuit will close during one-half of the cycle; if two contacts are used the circuit will close on both halves of the cycle. Thus the contacts may be closed at half-wave pulses or full-wave pulses, as desired.

The commutator type of synchronous rectifier employs a rotating arm with segmented pillars which is driven by a synchronous motor. Separate rectifying contacts are fixed in a

stationary position near the movable arm. These make contact with the commutator. The stationary and rotary segments are so arranged that the connections are reversed at the instant that the current reverses and in this manner rectify the alternating current to direct-current pulses.

**Ques. 3.109.** What might be the result of starting a motor too slowly, using a hand starter?

*Ans.* Starting a motor too slowly, using a hand starter, may burn out the resistance units in the starting box, as they are made for temporary duty only and cannot stand a heavy current flow for more than a very short period.

**Ques. 3.110.** State the principal advantage of a third-brush generator for radio power supply in automobiles.

*Ans.* The principal advantage of the third brush in a generator is to improve the voltage regulation under load changes.

**Ques. 3.111.** What materials should be used to clean the commutator of a motor or generator?

*Ans.* The commutator of the direct-current motor or generator is kept clean by polishing it with a piece of fine sandpaper, usually No. 0000. Emery cloth should never be used because it contains small metallic dust which would short-circuit the commutator segments. A piece of coarse canvas is also useful in giving the commutator a final polish. A special commutator paste is also available. This paste should be applied sparingly with a clean cloth and the commutator then polished while the machine is running.

**Ques. 3.112.** List three causes of sparking at the commutator of a direct-current motor.

*Ans.* There are many causes for excessive sparking at the brushes of a direct-current machine as follows:

## RADIO OPERATING QUESTIONS AND ANSWERS

1. Overloaded.
2. Poor brush fitting or worn brush.
3. Open in armature circuit.
4. High commutator bar.
5. Dirty commutator.
6. Too rapid starting.
7. Brushes off neutral point.

**Ques. 3.113.** Why is it necessary to use a starting resistance when starting a direct-current motor?

**Ans.** A starting resistance is necessary to prevent an excessive current flow in the armature of the motor before it gets up to speed. When the motor is up to running speed, the armature generates enough self-induced counter e.m.f. to keep the current in itself down to safe limits.

**Ques. 3.114.** List the comparative advantages and disadvantages of motor-generator and transformer-rectifier power supplies.

**Ans.** The answer may be tabulated as follows:

MOTOR GENERATOR	
ADVANTAGES	DISADVANTAGES
<ol style="list-style-type: none"><li>1. Easy voltage control.</li><li>2. Good regulation at full voltage.</li><li>3. Exceptionally rugged.</li><li>4. May be located at remote point.</li><li>5. May be operated from alternating-current or direct-current lines.</li><li>6. Very low maintenance costs.</li><li>7. Can stand considerable abuse.</li></ol>	<ol style="list-style-type: none"><li>1. Poor regulation at low voltages.</li><li>2. High first cost.</li><li>3. Difficult to repair.</li><li>4. May be noisy.</li><li>5. May cause vibration.</li><li>6. Requires constant attention to lubrication, commutator, and brushes.</li><li>7. May require long and dangerous high-voltage leads.</li><li>8. On direct-current generators output limited to about 12,000 volts.</li></ol>

## VACUUM-TUBE RECTIFIER

## ADVANTAGES

1. Lower first cost than motor generator.
2. No moving parts, hence no lubrication or other care aside from cleaning.
3. Exceptionally high voltages available without danger of breakdown.
4. Mercury-vapor type has good regulation.
5. Quiet in operation; no vibration.
6. Easier repair than motor generator.
7. Can be enclosed in transmitter unit, thus no exposed high-voltage leads.

## DISADVANTAGES

1. Necessity to replace tubes.
2. High maintenance costs.
3. Requires careful operation, cannot stand much abuse.
4. High-vacuum type has poor regulation.
5. Must be operated from alternating-current line.

**Ques. 3.115.** If the reluctance of an iron-cored choke is increased by increasing the air gap of the magnetic path, in what other way does this affect the properties of the choke?

*Ans.* The inductance will be decreased and the filtering action impaired. Core saturation will not occur.

**Ques. 3.116.** What is the effect upon a filter choke of a large value of direct-current flow?

*Ans.* The effect of a large value of direct-current flow upon a filter choke would be to cause it to heat up excessively. If the current flow is large enough the filter choke may burn out. Under any conditions an excessive direct-current flow will cause the choke to be saturated and have less inductance.

**Ques. 3.117.** What are the characteristics of a condenser-input filter system as compared to a choke-input system?

*Ans.* The condenser-input filter will give a higher voltage output than the choke-input system, but the regulation of the condenser-input system will not be so good. Instantaneous

peak rectifier current is much higher with capacity-input filters. This is particularly true if a mercury-vapor rectifier is used.

**Ques. 3.118.** What is the principal function of the filter in a power supply?

*Ans.* The principal function of the filter in a power-supply system is to iron out the peaks of the ripple frequency and to provide an output voltage which has a minimum fluctuation characteristic.

**Ques. 3.119.** What are the characteristics of a choke-input filter system as compared to a condenser-input system?

*Ans.* Other things being equal, the choke-input filter system will give better regulation than the condenser-input system, but the output voltage will be lower with the choke-input system. (See Ques. 3.117.)

**Ques. 3.120.** What is the percentage regulation of a power supply with a no-load voltage output of 126.5 volts and a full-load voltage output of 115 volts?

*Ans.* The percentage of regulation would be 10 per cent, computed by the formula

$$\text{Regulation per cent} = \frac{E_{max} - E_{min}}{E_{min}} \times 100.$$

**Ques. 3.121.** What is the definition of "voltage regulation" as applied to power supplies?

*Ans.* "Regulation," as applied to power supplies, is the difference between no-load and full-load voltage, expressed as a percentage of the full-load voltage.

$$\text{Regulation in per cent} = \frac{E_{nl} - E_{fl}}{E_{fl}} \times 100,$$

where  $E_{nl}$  is the no-load voltage.

$E_{fl}$  is the full-load voltage.

**Ques. 3.122.** May two condensers of 500 volts operating voltage, one an electrolytic and the other a paper condenser, be used successfully in series across a potential of 1,000 volts? Explain your answer.

*Ans.* If the voltage is of an alternating character this cannot be done since the electrolytic condenser operates upon the principle of unilateral conductivity. That is, it is a conductor during one portion of the alternating-current cycle. Obviously at this instant the paper condenser will be subjected to abnormal strain and will puncture. In direct-current circuits the arrangement may be used provided equalizing resistors are used and the electrolytic condenser possesses a very low power factor and proper polarity is observed.

**Ques. 3.123.** What is the principal function of a swinging choke in a filter system?

*Ans.* The swinging choke provides an inductance value which varies inversely with the current flow, thereby improving the regulation of the power supply. This is achieved by a small air gap which permits saturation with heavy current flow, with a consequent decrease in inductance.

**Ques. 3.124.** What is the purpose of a bleeder resistor as used in connection with power supplies?

*Ans.* The purpose of a bleeder as used in a filter system is to improve the regulation of the system. The bleeder also serves to discharge the filter condensers after shutdown, thus providing protection to the personnel against shock.

**Ques. 3.125.** What does a blue haze in the space between the filament and plate of a high-vacuum rectifier tube indicate?

*Ans.* A blue haze indicates the presence of gas in the tube and may mean that the tube is approaching the end of its useful life.

**Ques. 3.126.** When condensers are connected in series in order that the total operating voltage of the series connection is adequate for the output voltage of a filter system, what is the purpose of placing resistors of high value in shunt with each individual condenser?

*Ans.* To distribute the voltage strain equally between the condensers and to discharge the condensers after shutdown thus protecting the personnel against shock.

**Ques. 3.127.** If a high-vacuum type, high-voltage rectifier tube should suddenly show heavy internal sparking and then fail to operate, what elements of the rectifier-filter system should be checked for possible failure before installing a new rectifier tube.

*Ans.* The rectifier condensers.

**Ques. 3.128.** If the plate of a rectifier tube suddenly became red hot, what might be the cause and how could remedies be effected?

*Ans.* Short-circuited filter condensers, or excessive external load, which might be caused by improper adjustment of the radio-frequency circuit to which the rectifier tube supplies power.

**Ques. 3.129.** Draw a simple schematic diagram of a quartz-crystal-controlled oscillator, indicating the circuit elements necessary to identify this form of oscillatory circuit.

*Ans.* See Fig. 2-6.

**Ques. 3.130.** Draw a simple schematic diagram of a dynatron type of oscillator, indicating the circuit elements necessary to identify this form of oscillatory circuit.

*Ans.* See Fig. 3-12. This type of oscillator may be identified by the anode (*SG*) being at a higher potential than the plate. This condition is necessary to accomplish the

secondary emission on which the circuit depends for its operation.

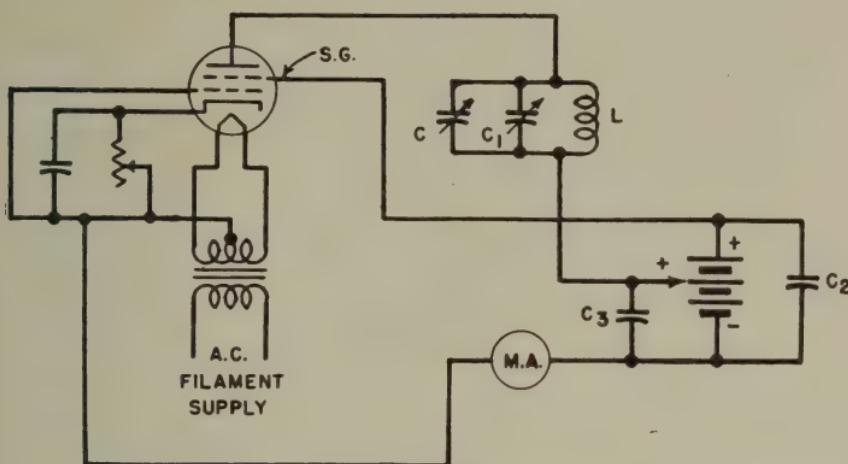


FIG. 3-12.—Dynatron oscillator.

**Ques. 3.131.** Draw a simple schematic diagram of an oscillatory circuit involving the use of a spark-gap discharge, indicating the circuit elements necessary to identify this form of oscillatory circuit.

*Ans.* See Fig. 3-13.

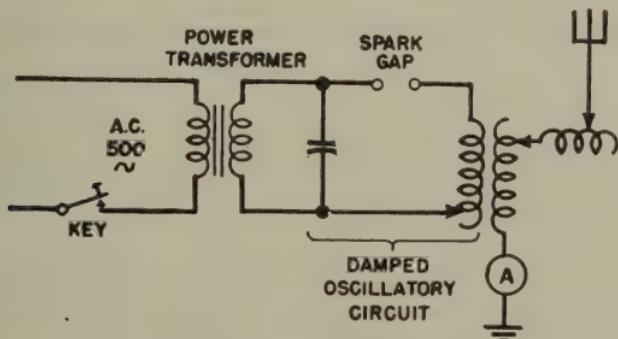


FIG. 3-13.—Fundamental spark transmitter.

**Ques. 3.132.** Draw a simple schematic diagram of an oscillating arc circuit, indicating the circuit elements necessary to identify this form of oscillatory circuit.

Ans. See Fig. 3-14.

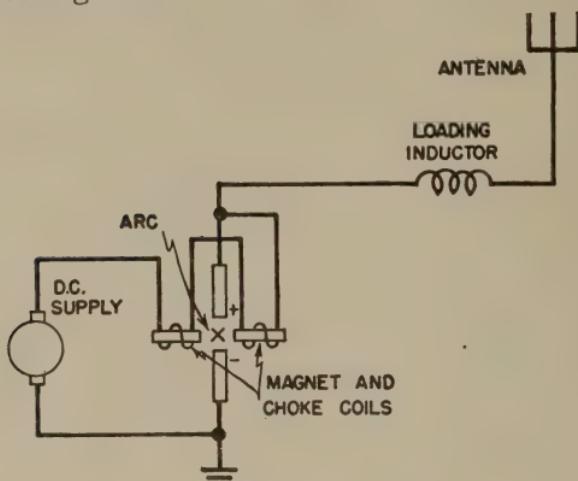


FIG. 3-14.—Fundamental oscillating arc.

**Ques. 3.133.** Draw a simple schematic diagram of an electron-coupled oscillator, indicating the circuit elements necessary to identify this form of oscillatory circuit.

*Ans.* See Fig. 2-9. In this type of circuit the plate element acts only as an output-coupling medium while the screen-grid element serves as the actual oscillator plate.

**Ques. 3.134.** What does the expression "positive temperature coefficient" mean, as applied to a quartz crystal?

*Ans.* The expression "positive temperature coefficient" means that the frequency of the crystal varies directly with the temperature; *i.e.*, when the temperature increases, the frequency of the crystal increases.

**Ques. 3.135.** Draw a simple schematic diagram of a crystal-controlled vacuum-tube oscillator using a pentode-type tube. Indicate power-supply polarity when necessary.

*Ans.* See Fig. 2-10.

**Ques. 3.136.** What will result if a direct-current potential is applied between the two parallel surfaces of a quartz crystal?

*Ans.* The parallel surfaces of a quartz crystal will either expand or contract, depending upon the polarity of the applied voltage. The crystal will not oscillate with a direct-current potential applied. If the applied potential is great enough in voltage value, the crystal will crack or split.

**Ques. 3.137.** What does the expression “negative temperature coefficient” mean, as applied to a quartz crystal?

*Ans.* The expression “negative temperature coefficient” means that the frequency of the crystal varies indirectly with the temperature; that is, when the temperature increases, the frequency of the crystal decreases.

**Ques. 3.138.** What does the expression “low temperature coefficient” mean, as applied to a quartz crystal?

*Ans.* The expression “low temperature coefficient” means that the frequency of the crystal varies very little with a change in temperature.

**Ques. 3.139.** What is the function of a quartz crystal in a radio transmitter?

*Ans.* The function of a quartz crystal in a radio transmitter is to keep the transmitter on its assigned frequency within the allowed frequency tolerances; *i.e.*, the quartz crystal functions as a frequency stabilizer.

**Ques. 3.140.** What may result if a high degree of coupling exists between the plate and grid circuits of a crystal-controlled oscillator?

*Ans.* A high degree of coupling between the plate and grid circuits of a crystal-controlled oscillator might result in excessive feedback with the danger of cracking the crystal.

**Ques. 3.141.** What is the purpose in maintaining the temperature of a quartz crystal as constant as possible?

## *RADIO OPERATING QUESTIONS AND ANSWERS*

*Ans.* It is necessary to keep the temperature of a quartz crystal constant in order to keep its oscillating frequency stable within limits.

**Ques. 3.142.** Why is a separate source of plate power desirable for a crystal-oscillator stage in a radio transmitter?

*Ans.* A separate source of plate power is desirable in order that the crystal-oscillator stage may operate with a maximum stability. If the crystal stage takes its power from the same source as the rest of the transmitter, and the regulation of the power supply is not up to the required standard for crystal stability, owing to variable load conditions in the power amplifier, the dynamic stability of the crystal frequency would be poor.

**Ques. 3.143.** What are the principle advantages of crystal-control over tuned-circuit oscillators?

*Ans.* The frequency variation in the crystal-controlled oscillator can be reduced to a lower maximum under all operating conditions than can the variation in a tuned-circuit oscillator.

**Ques. 3.144.** What is the approximate range of temperature coefficients to be encountered with X-cut quartz crystals?

*Ans.* From  $-10$  to  $-25$  parts per million (p.p.m.) per degree centigrade.

**Ques. 3.145.** It is necessary or desirable that the surfaces of a quartz crystal be clean? If so, what cleaning agents may be used which will not adversely affect the operation of the crystal?

*Ans.* Yes; it is necessary to keep the surfaces of a quartz crystal clean. This may best be done by using soap and water or carbon tetrachloride.

**Ques. 3.146.** Explain the generation of radio-frequency oscillations in a spark oscillatory circuit.

*Ans.* The spark-discharge oscillatory circuit consists of a transformer, which supplies power to the condenser of an oscillatory circuit consisting of a condenser, a spark gap, and an inductor in series. An analysis of the supply-line low-frequency charging cycle applied to the condenser would show that from 0 to 90 degrees of the charging cycle, the condenser charges. Electrostatic lines of force around the condenser are gradually increasing. As the charging cycle approaches 90 degrees, an excessive electrostatic strain is manifested between the points of the spark gap. When the potential difference across the spark gap reaches the rupture point there is a breaking up of air particles between the electrodes into ions. This is called *ionization* of the spark gap.

From 90 to 180 degrees on the charging cycle, the condenser discharges through the gap and the inductance, converting the electrostatic energy in the condenser into electromagnetic energy. Because of the "flywheel" effect of the oscillatory circuit, this energy charges the condenser in the opposite direction but to a decreased amplitude. The loss in energy is that caused by the dissipation of energy in the form of heat when the condenser made its first discharge through the gap and the inductance.

From 180 to 270 degrees, the same action as from 0 to 90 degrees takes place with the exception that the charge on the condenser is reversed owing to the reversal of the charging e.m.f. The energy involved has continued to decrease owing to heat and light losses.

From 270 to 360 degrees, the same action as from 90 to 180 degrees takes place. These cycles of discharge continue back and forth until all of the energy is dissipated in heat.

It can be seen from this explanation that the spark gap functions as a trigger or valve, and, therefore, if the coil is inductively coupled to a secondary coil connected in series with an

open radiating circuit, and both circuits are in tune, then the alternating field about the primary coil will cut the secondary and induce into it an e.m.f., which will set the antenna into oscillation and radiate damped waves. If the proper discharge is to be obtained, the gap spacing must be carefully adjusted.

If the gap electrodes are too close, the condenser will not receive a full charge and may discharge before 90 degrees of the charging cycle. On the other hand, if the gap electrodes are too far apart, then the condenser dielectric will be subjected to abnormal strain which will result in a puncture of the dielectric.

The period of damping in a circuit of this type is another important factor. For example, if the type of gap used does not radiate the heat quickly (deionize), then the oscillations will not die out very rapidly (low damping) and, consequently, will not permit a wave of low decrement to be emitted from the antenna system. This is due to reaction of the primary and secondary circuits on account of the high conductivity of the gap circuit.

Hence, for every discharge of the condenser through the spark gap and the inductance, the electrostatic energy is converted into electromagnetic energy about the inductance and the connecting wires, and, since the oscillations are of a high-frequency character and of a constantly changing polarity, the magnetic field about the inductance will be rising and falling at a definite frequency depending upon the values of the inductance and the capacity in the circuit. Thus radio-frequency oscillations will be generated.

**Ques. 3.147.** Explain the negative resistance characteristic of an oscillating arc circuit.

*Ans.* One type of oscillating arc circuit consists of a gaseous conductor of definite length and cross-section which is made up of ions which are greater in number than the electrons constituting the arc current. In the Poulsen arc generator, the electrodes are a hollowed copper anode, cooled by circulating water, and a carbon cathode, which is slowly rotated to insure

even burning. One of the characteristics of such an arc is that its resistance does not follow Ohm's law as do metals. Instead it has what is known as a "negative-resistance" characteristic. This means that the resistance decreases with a rise in voltage across the arc, owing to the fact that for a greater current flow the number of ions in the arc space is increased. This is equivalent to increasing the cross-section through which the arc current flows. (See Ques. 5.149.)

**Ques. 3.148.** List the characteristics of a dynatron type of oscillator.

*Ans.* The characteristics of a dynatron type of oscillator are as follows:

1. A well-designed dynatron has a frequency stability which compares favorably with that of the crystal oscillator without temperature control.
2. Its efficiency is low.
3. It can be used in a heterodyne wavemeter. When so used, the sharpness of indication of the meter is increased because the dynatron neutralizes the positive resistance of the wavemeter circuit. This it does by virtue of the negative resistance of the tube operating as a dynatron.

**Ques. 3.149.** List the characteristics of an electron-coupled type of oscillator.

*Ans.* The characteristics of an electron-coupled type of oscillator are as follows: In the electron-coupled oscillator, the plate circuit is isolated from its load. Hence, changes in load-circuit impedance do not effect the  $L \times C$  value in the oscillator circuit. Therefore, frequency stability is good. Modern practice is to use the electron-coupled oscillator in frequency meters because of its excellent frequency stability.

**Ques. 3.150.** Upon what characteristic of an electron tube does a dynatron type of oscillator depend?

*Ans.* Secondary emission.

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 3.151.** Describe a multivibrator and list its characteristics and uses.

*Ans.* The multivibrator or relaxation oscillator is a two-tube resistance-coupled oscillator in which the voltage developed by the output of the second tube is applied to the input of the first tube. The principle of operation is based upon the fact that the tubes invert the wave form. The output wave is nonsinusoidal in character. This type of oscillator may be used for any of the following purposes:

1. Master oscillator timer.
2. To produce rectangular control pulses of certain lengths, synchronized with excitation trigger pulses.
3. To introduce delay between input trigger pulses and a second circuit.
4. Frequency division. To synchronize or lock circuits at other than 1:1 ratio. See Fig. 4-19 for circuit diagram.

**Ques. 3.152.** If a wavemeter, having a deviation inversely proportional to the wavelength, is accurate to 10 cycles when set at 600 kilocycles, what is its error in cycles when set at 1,110 kilocycles?

*Ans.* The error is 18.5 cycles, computed as follows:

$$10:600 = x:1110; \quad x = 18.5.$$

**Ques. 3.153.** What precautions should be taken before using a heterodyne type of frequency meter?

*Ans.* The following precautions should be observed:

1. See that the filaments are operating at the proper voltage.
2. Be sure all high potential voltages are correct.
3. Be certain all holding screws on the cabinet are tight before checking or using the instrument. Any looseness involves capacity changes in the circuit, which will introduce errors in the calibration.

4. Make certain the meter has been recently checked against a calibrated test oscillator for frequency accuracy.
5. Let tubes warm up.

**Ques. 3.154.** What is the meaning of "zero beat" as used in connection with frequency-measuring equipment?

*Ans.* "Zero beat" means zero-beat frequency, which is the condition achieved when the frequency of the frequency-meter oscillator and that of the oscillations under measurement are equal. Hence, if the frequency of the frequency-meter oscillator is ascertainable on a calibrated dial, then, at "zero beat" the frequency of the oscillations being measured is that indicated on the calibrated dial.

Zero beat might also be defined as the condition under which maximum and minimum values of two different frequencies occur at the same instant.

**Ques. 3.155.** What precautions should be observed in using an absorption-type frequency meter to measure the frequency of a self-excited oscillator? Explain your reasons.

*Ans.* Place the instrument as far as workably possible from the circuit being measured to avoid mutual coupling reactions, which would alter the output frequency of the circuit being measured.

**Ques. 3.156.** If the first speech amplifier tube of a radiotelephone transmitter were overexcited, but the percentage modulation capabilities of the transmitter were not exceeded, what would be the effect upon the output of the transmitter?

*Ans.* Excessive distortion would result in the modulated amplifier and, consequently, in the radiated wave.

**Ques. 3.157.** What is the purpose of a preamplifier?

*Ans.* A preamplifier is used with certain low-output microphones such as a condenser microphone chiefly for two

purposes: first, to avoid cable loss ahead of the first stage of amplification thereby improving signal-to-noise ratio; secondly, to isolate the impedance of the cable and load from the microphone.

**Ques. 3.158.** What are the advantages of using two tubes in push-pull as compared with the use of the same tubes in parallel in an audio-frequency amplifier?

*Ans.* By operating two tubes in push-pull rather than in parallel a more symmetrical output wave form is secured, which conforms periodically to both sides of the excitation cycle, resulting in a neutralization of even harmonics.

**Ques. 3.159.** List four causes of distortion in a class A audio-frequency amplifier.

*Ans.* The following will cause distortion in a class A audio-frequency amplifier:

1. Too much excitation voltage.
2. Improper operating potentials.
3. Improper load impedance.
4. Leaky by-pass condensers.
5. Improper bias.
6. Parasitic oscillations.

**Ques. 3.160.** What is the purpose of by-pass condensers connected across audio-frequency amplifier cathode-bias resistors?

*Ans.* The purpose of the by-pass condensers is to provide a low impedance path for the audio-frequency components of the plate current to increase low-frequency response and signal amplitude.

**Ques. 3.161.** What are the advantages of using a resistor in series with the cathode of a class C radio-frequency amplifier tube to provide bias?

*Ans.* When this method is used, the tube is safeguarded against the removal of bias in the event of the failure of the independent bias supply. With this method, as long as a plate current flows a bias is provided. If the bias should be removed from a class C radio-frequency amplifier tube not provided with a resistor the plate current would immediately rise and possibly damage the tube.

**Ques. 3.162.** How may the generation of even harmonic energy in a radio-frequency amplifier stage be minimized?

*Ans.* The generation of even harmonic energy may be minimized by the use of the following:

1. Push-pull circuits with matched tubes.
2. Faraday screen.
3. Optimum ratio of volt-amperes to watts in the tank circuit.

**Ques. 3.163.** What tests will determine if a radio-frequency power-amplifier stage is properly neutralized?

*Ans.* Plate voltages only are removed from the tube, leaving the tube in its proper position in the circuit. Then test for the presence of radio-frequency current in the plate tank circuit of the tube whose neutralization is being tested. To do this, the preceding amplifier must be operating and an indicator of radio-frequency current, such as the thermocouple meter attached to a very small loop of wire, a neon bulb, or a low-power carbon-filament lamp, must be brought close to the tank circuit. If no radio-frequency current is present in the tank circuit, the tube is properly neutralized. If the presence of radio-frequency current is indicated in the tank circuit, the neutralizing condenser should be varied until it is indicated that this radio-frequency current in the tank circuit is at a minimum.

Excessive plate current in an amplifier stage might indicate

improper neutralization. Therefore, a proper reading on the plate-current ammeter would indicate proper neutralization of that stage. (See Ques. 5.98 and 3.170.)

**Ques. 3.164.** Why is the plate-circuit efficiency of a radio-frequency amplifier tube operating as class C higher than that of the same tube operating as class B? If the statement above is false, explain your reasons for such a conclusion.

*Ans.* The statement is true. The reason is that plate current flows only on the positive peaks of the excitation voltage at the instant when the voltage drop across the tube is low. Under these conditions, the largest portion of the plate power will be absorbed by the tuned plate circuit and transferred from there as useful output. (See Ques. 2.134.)

**Ques. 3.165.** Why does a class B audio-frequency amplifier stage require considerably greater driving power than a class A amplifier?

*Ans.* Because the grid of the class B amplifier is driven positive on the crest of each cycle and the grid input resistance of the tube is low. To avoid severe distortion the grid resistance must be very small so that the load on the driver does not change greatly when the grid goes positive. The low-resistance grid leak consumes a large amount of power. By contrast, the class A amplifier presents a high resistance at all times to the driver. Hence, it requires less driving power.

**Ques. 3.166.** Discuss the input circuit requirements for a class B audio-frequency amplifier grid circuit.

*Ans.* The most important consideration in the requirements of a class B amplifier is the proper design of the input circuit. The input to the grids of a class B audio-frequency amplifier is generally a balanced class A amplifier with a

high load-impedance primary. The secondary winding which feeds the grids of the class B stage is of low impedance and low resistance to handle the heavy grid-current swings. The heavy power demands also require a well-regulated plate and bias supply to keep distortion at a minimum.

**Ques. 3.167.** When a signal is impressed on the grid of a properly adjusted and operated class A audio-frequency amplifier, what change in average value of plate current will take place?

*Ans.* There will be no change in the average value of the plate current.

**Ques. 3.168.** If the value of capacitance of a coupling condenser in a resistance-coupled audio amplifier is increased, what effect may be noted?

*Ans.* If the capacitance of the coupling condenser is increased, the low-frequency response will be improved, but if the capacity is increased to an excessive value "motor-boating" or distortion may occur owing to a change in the time constants of the circuit.

**Ques. 3.169.** Why does a screen-grid tube normally require no neutralization when used as a radio-frequency amplifier?

*Ans.* Because the screen grid reduced the grid-to-plate capacity of the tube, which reduces the amount of feedback energy reaching the grid, thus preventing self-oscillation.

**Ques. 3.170.** What instruments or devices may be used to adjust and determine that an amplifier stage is properly neutralized?

*Ans.* Any of the following combinations may be used: a wavemeter in conjunction with a thermocouple galvanometer, a sensitive thermocoupled galvanometer connected in series with a small pick-up loop, a neon bulb or a low-power carbon-filament lamp connected in series with a pick-up loop. In modern broadcast transmitters it is generally unnecessary to use the above devices since each transmitter is equipped with an extra "sensitive" thermocouple shunt. This sensitive thermocouple is part of the regular tank-circuit radio-frequency ammeter. A pair of metal links are provided to switch the ammeter from the high-current thermocouple to the sensitive couple for neutralizing purposes.

Great care must be exercised that the sensitive thermocouple is not connected in the tank circuit during the period in which the plate voltages are applied since it will burn out immediately.

**Ques. 3.171. What is meant by the term unity "coupling"?**

*Ans.* When all the lines of force of one coil cut the windings of a second coil coupled to it and vice versa the coefficient of coupling is said to equal unity. A formula for coefficient of coupling is

$$k^2 = \frac{M^2}{L_p L_s},$$

where  $M$  is the mutual induction between the coils.

$L$  is the inductance value.

Under ordinary conditions, the value of  $k$  can approach, but never exceed, the value of unity. However, by the use of an iron core,  $k$  can be made almost equal to unity. Unity coupling is the condition when  $k$  equals unity or one.

**Ques. 3.172. Draw a diagram illustrating "capacitive" coupling between two tuned radio-frequency circuits.**

Ans. See Fig. 3-15.

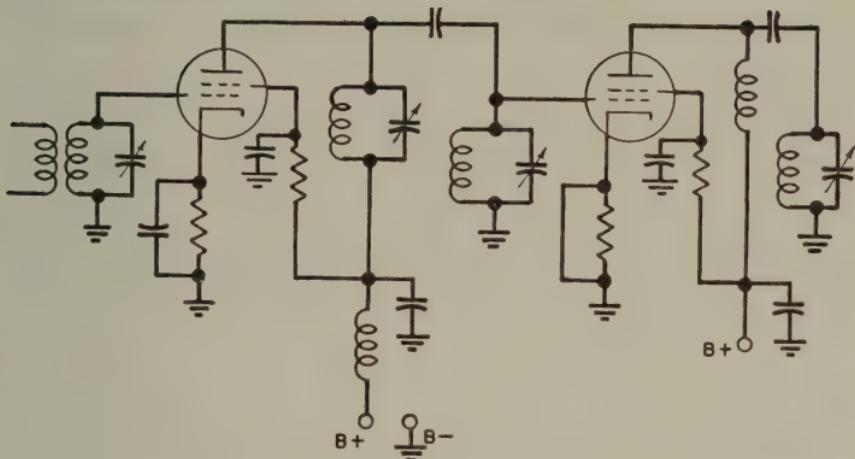


FIG. 3-15.—Capacitative coupling system.

Ques. 3.173. Draw a diagram illustrating inductive coupling between two tuned radio-frequency circuits.

Ans. See Fig. 2-16.

Ques. 3.174. Draw a diagram illustrating direct or Loftin-White coupling between two stages of audio-frequency amplification.

Ans. See Fig. 3-16.

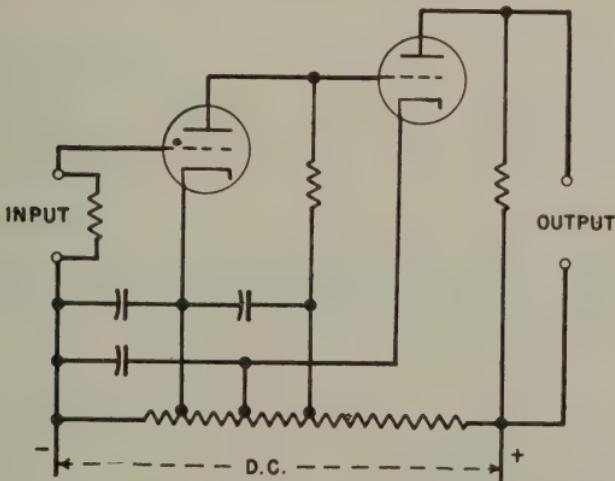


FIG. 3-16.—Loftin-White direct-coupled amplifier.

**Ques. 3.175.** List four classes of stations which may be operated by a person holding a radiotelephone second-class license.

*Ans.* Any station while using type A0, A3, A4, or A5 emission except standard broadcast stations, International broadcast stations, or ship stations licensed to use power in excess of 100 watts and type A3 emission for communication with coastal telephone stations. Such stations might include any of the following:

1. General experimental.
2. Aeronautical.
3. Municipal police.
4. Television broadcast.

**Ques. 3.176.** List four classes of broadcast stations which may be operated by the holder of a radiotelephone second-class operator license.

*Ans.*

1. Experimental broadcast.
2. Relay broadcast.
3. Facsimile broadcast.
4. Television broadcast.

**Ques. 3.177.** May the holder of a radiotelephone second-class operator license adjust and service or supervise the adjustment and servicing of any class of police radio station?

*Ans.* Yes, as long as such station is using type A3 emission.

**Ques. 3.178.** List four classes of stations, the equipment of which may be adjusted and serviced by the holder of a radiotelephone second-class operator license.

*Ans.*

1. General experimental.
2. Aeronautical.

3. Municipal police.
4. Television broadcast.

**Ques. 3.179.** List three classes of stations which may not be serviced or adjusted by the holder of a radiotelephone second-class operator license.

*Ans.*

1. Standard broadcast.
2. Ship station compulsorily equipped.
3. Zone police station.

**Ques. 3.180.** If an operator is employed at more than one station, how may the requirements of the Commission's Rules and Regulations be met with respect to the posting of operator licenses?

*Ans.* The holder of an operator license who operates any station in which the posting of an operator license is not required, may, upon filing application in duplicate, accompanied by his license, obtain a verification card. This card may be carried on the person of the operator in lieu of the original operator license, provided the license is readily accessible within a reasonable time for inspection upon demand by an authorized Government representative.

The original license of each station operator shall be posted at the (principal) place where he is on duty or kept in his possession in the manner specified in the regulations governing the class of station concerned.

**Ques. 3.181.** Is it necessary that the original operator license be posted at an aeronautical station? An aircraft station? An airport station? A broadcast station? A ship station?

*Ans.* The original license of each station operator shall be conspicuously posted at the place he is on duty, or, in the case of mobile units, either the license or verification card must be kept in his personal possession.

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 3.182.** What is a "verification card" and under what circumstances may it be used?

*Ans.* The holder of an operator license who operates any station in which the posting of an operator license is not required, may, upon filing application in duplicate, accompanied by his license, obtain a "verification card." This card may be carried on the person of the operator in lieu of the original operator license, provided the license is readily accessible within a reasonable time for inspection upon demand by an authorized Government representative.

**Ques. 3.183.** If a ship-telephone station is assigned the frequency of 2,738 kilocycles, and the maximum tolerance is 0.04 per cent, what are the highest and lowest frequencies within the tolerance limits?

*Ans.* 2,736.9 kilocycles and 2,739.1 kilocycles.

**Ques. 3.184.** If an aircraft station is assigned the frequency of 3,105 kilocycles, and the maximum tolerance is 0.1 per cent, what are the highest and lowest frequencies within the tolerance limits?

*Ans.* 3,101.9 kilocycles and 3,108.1 kilocycles.

**Ques. 3.185.** If a heterodyne frequency meter, having a calibrated range of 1,000 to 5,000 kilocycles, is used to measure the frequency of a transmitter operating on approximately 500 kilocycles by measurement of the second harmonic of this transmitter, and the indicated measurement was 1,008 kilocycles, what is the actual frequency of the transmitter output?

*Ans.* 504 kilocycles.

**Ques. 3.186.** Under what conditions may a log not be maintained by a radio station in the aviation or emergency service?

*Ans.* During an emergency the log may be neglected but must be made up immediately following the emergency and initialed by a person, other than the operator, who was present during the emergency.

**Ques. 3.187.** What information must be entered in the radio station log of an aircraft station not open to public service?

*Ans.* According to Rule 9.41 of the FCC which is quoted in the preceding answer, an aircraft station is not required to keep a log. However, if a log is kept, the information listed under Items 1, 2, 3, and 4 in the following answer should be entered.

**Ques. 3.188.** List four entries required to be entered in the radio station log of a station in the aviation service.

*Ans.* All stations in the aviation service, except aircraft stations, must keep an adequate log showing (1) hours of operation, (2) frequencies used, (3) stations with which communication was held, and (4) signature of operator(s) on duty.

**Ques. 3.189.** List four entries required to be entered in the radio station log of a station in the emergency service.

*Ans.* Each licensee shall maintain adequate records of the operation of the station, including (1) hours of operation; (2) frequencies used; (3) nature and time of each transmission; (4) name of operator on duty at the transmitter.

**AUTHOR'S NOTE**—In addition to the above items to be noted in the log, it is evident that anything of special significance not covered by the above items should also be entered in the log.

**Ques. 3.190. Define the following types of emission: A0, A1, A2, A3, A4, A5.**

*Ans.* Type A0. Waves the successive oscillations of which are *identical* under fixed conditions. (Standard frequency transmission.)

## RADIO OPERATING QUESTIONS AND ANSWERS

*Type A1.* Telegraphy on pure continuous waves. A continuous wave which is keyed according to a telegraph code.

*Type A2.* Modulated telegraphy. A carrier wave modulated at one or more audible frequencies; the audible frequency or frequencies or their combination with the carrier wave being keyed according to a telegraph code.

*Type A3.* Telephony. Waves resulting from the modulation of a carrier wave by frequencies corresponding to the voice, to music, or to other sounds.

*Type A4.* Facsimile. Waves resulting from the modulation of a carrier wave by frequencies produced at the time of the scanning of a fixed image with a view to its reproduction in a permanent form.

*Type A5.* Television. Waves resulting from the modulation of a carrier wave by frequencies produced at the time of the scanning of fixed or moving objects.

In addition to the continuous-wave emissions, which are classed as type A, there is the type B emission, which is composed of successive series of oscillations the amplitude of which, after attaining a maximum, decreases gradually, the wave trains being keyed according to a telegraph code.

**Ques. 3.191. What is the radiotelephone distress signal?**

*Ans.* In radiotelephony, the distress signal shall consist of the spoken expression MAYDAY (corresponding to the French pronunciation of the expression *m'aider*).

**Ques. 3.192. What is the radiotelephone safety signal?**

*Ans.* In radiotelephony, the word SECURITY (corresponding to the French pronunciation of the word *sécurité*), repeated three times, shall be used as the safety signal.

**Ques. 3.193. What is indicated if the signal SECURITY is intercepted?**

*Ans.* The safety signal SECURITY announces that the transmitting station is about to send a message concerning

the safety of navigation or giving important meteorological warnings.

**Ques. 3.194.** What is indicated if the signal PAN is intercepted?

*Ans.* The urgent signal shall indicate that the calling station has a very urgent message to transmit concerning the safety of a ship, an aircraft, or another vehicle, or concerning the safety of some person on board or sighted from on board.

**Ques. 3.195.** If an operator should intercept the signal PAN transmitted by radiotelephony, what should he do?

*Ans.* The urgent signal shall have priority over all other communications, except distress communications, and all mobile or land stations hearing it must take care not to interfere with the transmission of the message which follows the urgent signal.

**Ques. 3.196.** What are the circumstances under which the safety signal should be transmitted by radiotelephony?

*Ans.* The safety signal (SECURITY) announces that the transmitting station is about to send a message concerning the safety of navigation or giving important meterological warnings.

**Ques. 3.197.** In the adjustment of a radiotelephone transmitter, what precautions should be observed?

*Ans.* Tests and experiments are permitted to certain stations provided they do not interfere with the services of other stations. The operator should make certain before each test or adjustment that such interference will not take place.

**Ques. 3.198.** Which classes of stations have no power limitations prescribed by the Commission?

## *RADIO OPERATING QUESTIONS AND ANSWERS*

*Ans.* Fixed municipal and state police radio stations may operate on unlimited power on certain frequencies in the 30-to 40-megacycle band.

**Ques. 3.199.** If an operator should wilfully and maliciously interfere with any radio communications or signals other than distress, what penalties would he be subject to?

*Ans.* Any person who wilfully and knowingly violates any rule, regulation, restriction, or condition made or imposed by the Commission under authority of this Act, or any rule, regulation, restriction, or condition made or imposed by any international radio or wire communications treaty or convention, or regulations annexed thereto, to which the United States is or may hereafter become a party, shall, in addition to any other penalties provided by law, be punished, upon conviction thereof, by a fine of not more than \$500 for each and every day during which such offense occurs. The operator may also have his license revoked.

**Ques. 3.200.** Under what circumstances may messages concerning the detection or prevention of crime be exchanged by radiotelephone between municipal police radio stations?

*Ans.* Municipal police stations, although licensed primarily for communication with mobile police units, may transmit emergency messages to other mobile units such as fire-department vehicles, private ambulances, and repair units of public utilities, in those cases which require cooperation or coordination with police activities. In addition, such stations may communicate among themselves provided (1) that no interference is caused to the mobile service, and (2) that communication is limited to places between which, by reason of their close proximity, the use of police radiotelegraph stations is impracticable. Municipal police stations shall not engage in point-to-point radio communication beyond the good service range of the transmitting station or

transmit or handle communications requiring radiotelephone relay. Point-to-point communication between stations in the same local telephone exchange area is prohibited unless the messages are of immediate importance to mobile units.

**Ques. 3.201.** What is the meaning of "a station open to public service"?

*Ans.* A station open to public correspondence at published rates; that is, a paid or toll message service.

**Ques. 3.202.** Under what circumstances may an aircraft radio station call an airport station on 3,105 kilocycles?

*Ans.* The use of this frequency is restricted to communications pertaining solely to aircraft operation and the protection of life and property. This frequency is also a calling and working frequency for use primarily by nonscheduled aircraft.

**Ques. 3.203.** If, upon being called by another station, a called station is unable to proceed with the acceptance of traffic without a slight delay, what procedure should be adopted by the operator?

*Ans.* If the station called is prevented from receiving, it shall reply to the call as indicated in the Regulations, but it shall replace the letter K by the signal . — . . . (wait), followed by a number indicating in minutes the probable duration of the wait. If this probable duration exceeds 10 minutes (5 minutes in the aeronautical mobile service), a reason must be given therefor.

**Ques. 3.204.** To what aircraft is an aeronautical station required to provide nonpublic service?

*Ans.* Aeronautical stations shall provide nonpublic service without discrimination to all scheduled aircraft the owners of which make cooperative arrangements for the operation and maintenance of the aeronautical stations which are to furnish

such service and for shared liability in the operation of stations. In addition, this class of station shall provide reasonable and fair service to nonscheduled aircraft in accordance with the provisions of these rules.

**Ques. 3.205. Is an aeronautical station permitted to transmit messages?**

*Ans.* All stations in the aviation service, except those stations licensed for public aviation service, shall transmit only communications relating to and necessary for aircraft operation and the protection of life and property in the air.

**Ques. 3.206. In what kind of communications may an experimental station engage?**

*Ans.* Experimental stations shall not be used to conduct general message traffic of any kind, to demonstrate equipment for prospective sales purposes, to transmit programs for direct entertainment, to transmit the programs of any other station, except in conjunction with experimental programs, or to render any commercial communication service or communications involving advertising, either directly or indirectly, subject to specific limitations and restrictions which will be prescribed in individual cases by the Commission. This authority will be granted only for special reasons to obtain information or data which gives promise of being of benefit to the radio art.

**Ques. 3.207. Under what circumstances will remote control of a radio transmitter, other than broadcast, with the operator at a point other than the location of the transmitter, be authorized by the Commission?**

*Ans.* A licensed operator shall be on duty and in charge of the transmitter during all transmissions unless remote-control operation or operation without an operator in attendance is authorized by the terms of the instrument of authorization.

**Ques. 3.208.** Under what circumstances may aircraft equipment be tested in flight?

*Ans.* The licensees of all classes of stations in the aviation service are authorized to make such routine tests as may be required for the proper maintenance of the station provided that precautions are taken to avoid interference with any station. Tests on 3,105 and 6,210 kilocycles using a regular antenna system can be made only at such times when no interference will be caused and, if in range of an airport control station or Civil Aeronautics Authority station, only after permission is secured from such stations before commencing the tests.

**Ques. 3.209.** At all broadcast stations for which a second-class radiotelephone operator license is valid, how often must the frequency of emission be checked?

*Ans.* The frequency of these stations should be checked at each time of beginning operation and as often thereafter as necessary to maintain the frequency within the allowed tolerance.

**Ques. 3.210.** Explain the relation between the signal frequency, the oscillator frequency, and the image frequency in a superheterodyne receiver.

*Ans.* The image frequency is as far above the oscillator frequency as the signal frequency is below the oscillator frequency or vice versa. The difference between the oscillator frequency and the signal frequency equals the intermediate frequency. The difference between the oscillator frequency and the image frequency also equals the intermediate frequency.

**Ques. 3.211.** What means are used to prevent interaction between the stages of a multistage audio-frequency amplifier?

*Ans.* Adequate filters must be provided where necessary and the various components oriented to the optimum position for minimum reaction between components. Iron shields are useful in keeping down this reaction. It is sometimes useful to ground the shields.

**Ques. 3.212.** Under what conditions, if any, may a station be operated by an unlicensed person or by an operator not holding a license of the grade normally required for that station?

*Ans.* The Commission, if it shall find that the public interest, convenience, or necessity will be served thereby, may waive or modify the law which requires a licensed operator of a specified grade at each transmitting station except (1) at stations for which a licensed operator is required by international agreement, (2) at stations for which licensed operators are required for safety purposes, (3) at stations engaged in broadcasting, or (4) at stations operating as common carriers on frequencies below 30,000 kilocycles. Hence, in an emergency the Commission may permit certain stations to be operated by a grade of operator not required in the regulations.

**Ques. 3.213.** For what period of time must a log containing distress entries be retained?

*Ans.* Logs containing distress entries shall be retained by the licensee until specifically authorized in writing by the Commission to destroy them.

**Ques. 3.214.** If the load is removed from the secondary of the output transformer of a class B audio-frequency amplifier, what would be the effect?

*Ans.* The primary voltage will rise excessively. The excessive strain developed across the primary winding may result in a breakdown of the winding.

**Ques. 3.215.** A radio-frequency amplifier has a plate voltage of 1,000 volts, plate current of 100 milliamperes, a grid current of 10 milliamperes, and a cathode resistor of 200 ohms. Find the total plate d-c input power.

*Ans. Solution:*

Total plate circuit d-c input power dissipated is 100 watts.

$$\text{d-c input power} = E_B \times I_B = \text{watts.}$$

However, 2 watts is dissipated in the cathode resistor. Therefore, a total power loss and output power of 98 watts will be expended in the tube plate and load components, respectively. It should be noted that the grid current flow is not included in the plate power supply since that current is supplied by the grid-driver source.

## ELEMENT 4

### ADVANCED RADIOTELEPHONY

**Ques. 4.01.** A parallel circuit is made up of five branches, three of the branches being pure resistances of 7, 11, and 14 ohms, respectively. The fourth branch has an inductive reactance value of 500 ohms. The fifth branch has a capacitive reactance of 900 ohms. What is the total impedance of the network? If a voltage is impressed across the parallel network, which branch will dissipate the greatest amount of heat?

*Ans.* The first step in a problem of this character is to reduce the three parallel resistances to their effective or singular equivalent value.

$$R_{\text{eff}} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} = 3.27 \text{ ohms.}$$

Thus, a single resistance equivalent of 3.27 ohms is connected in parallel to an inductive reactance value of 500 ohms and a capacitive reactance of 900 ohms. Obviously, this low value of resistance in shunt to the two higher reactances will make the circuit impedance somewhere in the vicinity of 3+ ohms. To prove this contention, however, let us apply some arbitrary value of voltage to this combination of, say, 900 volts. The currents through the various branches may then be readily determined by Ohm's law,  $I = \frac{E}{R}$ ,  $I = \frac{E}{X_L}$ ,  $I = \frac{E}{X_C}$ . The total line current may then be obtained by the equation,

$$I_{\text{line}} = \sqrt{I_R^2 + (I_L - I_C)^2} = 276 \text{ amperes}$$

Thus,

$$Z = \frac{E}{I} = \frac{900}{276} = 3.26 \text{ ohms.}$$

The greatest amount of heat will be dissipated by the 7-ohm unit.

**Ques. 4.02.** What is the reactance of a condenser at the frequency of 1,200 kilocycles if its reactance is 300 ohms at 680 kilocycles?

*Ans.* The correct answer is 170 ohms.

*Solution:*

$$\begin{aligned}\frac{Xc_1}{Xc_2} &= \frac{f_2}{f_1} \\ \frac{300}{Xc_2} &= \frac{1,200}{680} \\ Xc_2 &= 170 \text{ ohms.}\end{aligned}$$

**Ques. 4.03.** If the mutual inductance between two coils is 0.1 henry, and the coils have inductances of 0.2 and 0.8 henry, respectively, what is the coefficient of coupling?

*Ans.* The coefficient of coupling is 0.25.

*Solution:*

$$k = \frac{M}{\sqrt{L_1 \times L_2}} = \frac{0.1}{\sqrt{0.2 \times 0.8}} = 0.25 \text{ (25 per cent).}$$

**Ques. 4.04.** If, in a given alternating-current series circuit, the resistance, inductive reactance, and capacitive reactances are of equal magnitude of 11 ohms, and the frequency is reduced to 0.411 of its value at resonance, what is the resultant impedance of the circuit at the new frequency?

*Ans.* The resultant impedance of the circuit at the new frequency is 24.8 ohms.

*Solution:*

$$X_L = 11, \quad X_c = 11; \quad R = 11 \\ X'_L = 0.411 \times 11 = 4.52$$

$$X'_c \frac{11}{0.411} = 26.76; \quad \text{New } X = X'_c - X'_L = 22.24 \text{ ohms.} \\ Z' = \sqrt{R^2 + X^2} = 24.8 \text{ ohms.}$$

**Ques. 4.05.** How many single-phase wattmeters are required to measure power in a three phase alternating-current circuit? Describe how this is done.

**Ans.** Two wattmeters are generally used to measure the power in a balanced three-phase Y- or delta-connected network. The algebraic sum of the readings of the two wattmeters, if properly connected, gives the true power reading. Figure 4-1 illustrates the connection method.

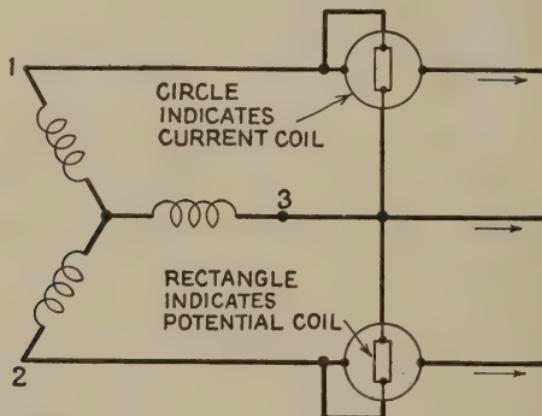


FIG. 4-1.—Three-phase wattmeter connections.

In taking the readings from the wattmeters, care must be taken to see whether both wattmeters are connected alike or differently. If corresponding ends of the potential coils are connected to the common line, the meters are connected alike. If the meters then read upscale, their readings are positive. If the wattmeters are of a different type, or make, they may both be first placed in the same circuit to determine which terminals correspond.

**Ques. 4.06.** If an alternating current of 5 amperes flows in a series circuit composed of 12 ohms resistance, 15 ohms inductive reactance, and 40 ohms capacitive reactance, what is the voltage across the circuit?

*Ans.* The voltage across the circuit is 138.7 volts.

*Solution:*

$$E_A = \sqrt{E_R^2 + (E_c - E_L)^2} = \sqrt{3,600 + 15,625} = 138.7 \text{ volts}$$

$$E_R = IR = 5 \times 12 = 60 \text{ volts.}$$

$$E_c = IX_c = 5 \times 40 = 200 \text{ volts.}$$

$$E_L = IX_L = 5 \times 15 = 75 \text{ volts.}$$

**Ques. 4.07.** A series circuit contains resistance, inductive reactance, capacitive reactance. The resistance is 7 ohms, the inductive reactance is 8 ohms, and the capacitive reactance is unknown. What is the value of the condenser reactance in order that the total circuit impedance is 13 ohms?

*Ans.* The capacitive reactance value must be 18.96 ohms.

*Solutions:*

$$Z = \sqrt{R^2 + X^2} = 169 = 49 + X^2 \quad X^2 = 120 \quad X = \pm 10.96$$

$$\text{but } X = X_L - X_c \quad \therefore \pm 10.96 = 8 - X_c$$

$$X_c = 8 + 10.96 = 18.96$$

*Proof:*

$$Z = \sqrt{R^2 + (X_c - X_L)^2} = \sqrt{49 + 120} = \sqrt{169} = 13 \text{ ohms.}$$

**Ques. 4.08.** What is the total reactance of two inductances connected in series with zero mutual inductance?

*Ans.* The total reactance with zero mutual inductance is the sum of the two individual reactances,  $X_1 + X_2$ .

**Ques. 4.09.** If an alternating voltage of 115 volts is connected across a parallel circuit made up of a resistance of

30 ohms, an inductive reactance of 17 ohms, and a capacitive reactance of 19 ohms, what is the total circuit-current drain from the source?

*Ans.* The total current drain is 3.9 amperes.

*Solution:*

$$I_{\text{line}} = \sqrt{I_R^2 + (I_L - I_c)^2} = \sqrt{14.7 + .5} = 3.9 \text{ amperes.}$$

$$I_R = \frac{E}{R} = 3.83 \text{ amperes,} \quad I_L = \frac{E}{X_L} = 6.76 \text{ amperes,}$$

$$I_c = \frac{E}{X_c} = 6 \text{ amperes.}$$

**Ques. 4.10.** When two coils, of equal inductance, are connected in series, with unity coefficient of coupling and their fields in phase, what is the total inductance of the two coils?

*Ans.* The total inductance is the sum of the two equal inductances plus the product of  $2M$ , or  $4 \times L_1$  or  $4 \times L_2$ .

*Solution:*

$$M = \sqrt{L_1 \times L_2} \quad L_x = L_1 + L_2 + 2M$$

**Ques. 4.11.** If a transformer has a primary voltage of 4,400 volts and a secondary voltage of 220 volts, and the transformer has an efficiency of 98 per cent when delivering 23 amperes of secondary current, what is the value of primary current?

*Ans.* The current flow at 98 per cent efficiency is approximately 1.17 amperes.

*Solution:*

$$I_p = \frac{E_s \times I_s}{E_p} = 1.15 \text{ amperes at 100 per cent efficiency.}$$

$$P_p = \frac{220 \times 23}{0.98}$$

$$I_p = \frac{P_p}{E_p} = \frac{5,170}{4,400} = 1.175 \text{ amperes.}$$

Thus, at 98 per cent efficiency the value of primary current is 1.17 amperes.

**Ques. 4.12.** Why is it impossible to obtain unity coupling in radio-frequency transformers?

*Ans.* Unity coupling in radio-frequency transformers is impossible because the magnetic leakage through the air prevents complete linkage. Unity coupling can only be approached with closed iron-core coils in which each line of force developed around a primary winding interlinks with the secondary winding. If closed iron cores are used in radio-frequency transformers, no radio frequencies (excepting those which may pass through the distributed capacity of the windings) would be transferred owing to the high impedance of closed iron-core coils at high frequencies.

**Ques. 4.13.** Three single-phase transformers, each with a ratio of 220 to 2,200 volts are connected across a 220-volt three-phase line, primaries in delta. If the secondaries are connected in Y, what is the secondary line voltage?

*Ans.* In a delta-Y connected transformer system the output voltage across the secondary may be computed from the formula,

$$E_s = E_p \times T_r \times 1.73$$

where  $E_s$  = secondary voltage.

$T_r$  = transformation ratio.

$E_p$  = primary voltage.

Thus, in this example, the secondary voltage is 3,806 volts.

**Ques. 4.14.** What factors determine core losses in a transformer?

*Ans.* The character of the core material and the physical structure of the core material. The core losses in trans-

formers are mainly due to molecular friction or hysteresis and eddy currents. These are minimized by the use of special core material, such as silicon steel, and the arrangement of the core into sheets or laminations.

**Ques. 4.15.** What circuit constants determine the copper losses of a transformer?

*Ans.* The copper losses are primarily dependent upon the circuit load. These losses are generally expressed as the  $I^2R$  losses. The proper size of wire for given load conditions is essential to keep these losses at a minimum.

**Ques. 4.16.** Draw a schematic wiring diagram of a three-phase transformer with delta-connected primary and Y-connected secondary.

*Ans.* Figure 4-2 illustrates a delta-Y-connected transformer.

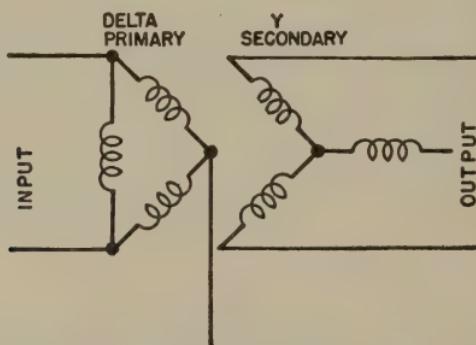


FIG. 4-2.—Delta-star or Y transformer.

**Ques. 4.17.** (a) In a class A power amplifier, what ratio of load impedance to dynamic plate impedance will result in maximum power being absorbed by the load impedance? (b) What is the plate efficiency under this condition of operation?

*Ans.* (a) A ratio of 1:1 will satisfy this condition provided the grid swing is constant and of small amplitude. (b) The

plate efficiency is dependent upon the amplitude of the applied grid signal voltage and may vary between 0 and approximately 16 per cent. However, under conditions of large grid swing, the ratio of plate load to tube impedance for optimum power should be approximately 2:1. Under this condition of operation the plate efficiency is 25 per cent.

It should be noted that the theoretical maximum plate efficiency for an idealized triode amplifier is 50 per cent. This value is obtained for a ratio of load impedance to tube plate impedance of infinity to one and under this condition the power output is zero.

**Ques. 4.18.** What factor(s) determine the ratio of impedances which a given transformer can match?

*Ans.* The turns ratio.

$$\text{Turns ratio} = \sqrt{\frac{Z_p}{Z_s}}$$

**Ques. 4.19.** If a transformer, having a turns ratio of 10:1, working into a load impedance of 2,000 ohms and out of a circuit having an impedance of 15 ohms, what value of resistance may be connected across the load to effect an impedance match?

*Ans.* A load resistance of 6,000 ohms will effect an approximate match.

*Solution:*

$$\frac{n_1}{n_2} = \sqrt{\frac{Z_1}{Z_2}} \quad \left(\frac{n_2}{n_1}\right)^2 = \frac{Z_2}{Z_1}$$

$$100 = \frac{Z_2}{15}$$

$$1,500 = Z_2$$

∴  $R_x$  must be of such value as to give 1,500 ohms when in parallel with 2,000 ohms.

$$R_{\text{total}} = \frac{2,000R_x}{2,000 + R_x}$$

$$1,500(2,000 + R_x) = 2,000R_x$$

$$6,000 + 3R_x = 4R_x$$

$$6,000 = 4R_x - 3R_x = R_x$$

$$R_x = 6,000 \text{ ohms.}$$

**Ques. 4.20.** What is the purpose of effecting impedance matches in radio equipment?

*Ans.* Impedance matching is required to permit a maximum absorption of power from a source to a load. Maximum power is transferred from any source to a load under those conditions only when the load resistance or impedance value is equal to the source value. Load matching also prevents line reflections and standing waves in transmission lines.

**Ques. 4.21.** In a class C radio-frequency power amplifier, what ratio of load impedance to plate impedance will give the greatest plate efficiency?

*Ans.* The theoretical ratio is infinity to one. For practical purposes this ratio is generally 4:1.

**Ques. 4.22.** If a lamp, rated at 100 watts and 115 volts, is connected in series with an inductive reactance of 355 ohms and a capacitive reactance of 130 ohms across a voltage of 220 volts, what is the current through the lamp?

*Ans.* The current flow through the lamp is approximately 0.86 ampere.

*Solution:*

$$R_{\text{lamp}} = 132 \text{ ohms (approx.)}$$

$$I = \frac{E}{Z} = \frac{220}{\sqrt{R^2 + (X_l - X_c)^2}} = 0.86 \text{ ampere (approx.)}$$

**Ques. 4.23.** If an alternating-current series circuit has a resistance of 12 ohms, an inductive and capacitive reactance of 7 ohms, at the resonant frequency, what will be the total impedance at twice the resonant frequency?

*Ans.* The impedance will be approximately 15.9 ohms.

*Solution:*

$$2X_L = 14 \text{ ohms} \quad Z = \sqrt{R^2 + (X_L - X_C)^2} = 15.9 \text{ ohms.}$$

$$\frac{1}{2}X_C = 3.5 \text{ ohms}$$

**Ques. 4.24.** In a parallel circuit composed of an inductance of 150 microhenrys and a capacitance of 160 micromicrofarads, what is the resonant frequency?

*Ans.* The resonant frequency is 1,028 kilocycles.

*Solution:*

$$f_r = \frac{10^6}{2\pi\sqrt{LC}} = 1,028 \text{ kilocycles.}$$

**Ques. 4.25.** What value of capacitance must be shunted across a coil having an inductance of 56 microhenrys in order that the circuit resonate at 5,000 kilocycles?

*Ans.* Approximately 18 micromicrofarads.

*Solution:*

$$C_{\text{farads}} = \frac{1}{4\pi^2 f^2 L} = 18 \text{ micromicrofarads}$$

**Ques. 4.26.** Why may it be desirable to ground all components of a speech amplifier at a common point?

*Ans.* It is generally desirable to connect all components at a common point to maintain low potential difference levels

## *RADIO OPERATING QUESTIONS AND ANSWERS*

between them. Common point terminations and grounding prevent amplifier instability and coupling difficulties.

**Ques. 4.27.** Why should impedances be matched in speech-input equipment?

**Ans.** Impedances should be matched to effect a maximum energy transfer and minimum line reflections. Improper impedance matching in speech amplifier circuits might not only decrease the volume, but might seriously affect the quality of reproduction. A piece of cable that is electrically short and is terminated in a resistance higher than its characteristic resistance is equivalent to a shunt capacity.

**Ques. 4.28.** What are the purposes of *H* or *T* pad attenuators?

**Ans.** Attenuators of the *H* and *T* pad variety effect proper impedance matching with desired attenuation.

**Ques. 4.29.** Why are grounded center-tap transformers frequently used to terminate program lines?

**Ans.** They effect a proper balance to ground. This will cause a reduction in stray field pick-up and also balance out unwanted line noises. The frequency response is also improved.

**Ques. 4.30.** What is the purpose of a line pad?

**Ans.** A line pad serves to introduce a proper amount of attenuation and at the same time effect an impedance match.

**Ques. 4.31.** Why are electrostatic shields used between windings in coupling transformers?

**Ans.** Electrostatic shields between windings in coupling transformers reduce the capacitive coupling between coils.

The coupling is thereby made more purely magnetic. They also serve to reduce the output-to-input circuit transfer. Line noises and radio-frequency pick-up transfer are greatly minimized. In radio-frequency coupling transformers the electrostatic shield reduces harmonic transfer and greatly increases circuit stability.

**Ques. 4.32.** Draw a simple diagram showing four mixers connected in series-parallel, using compensating resistors and feeding a balanced load with proper matching.

**Ans.** See Fig. 4-3.

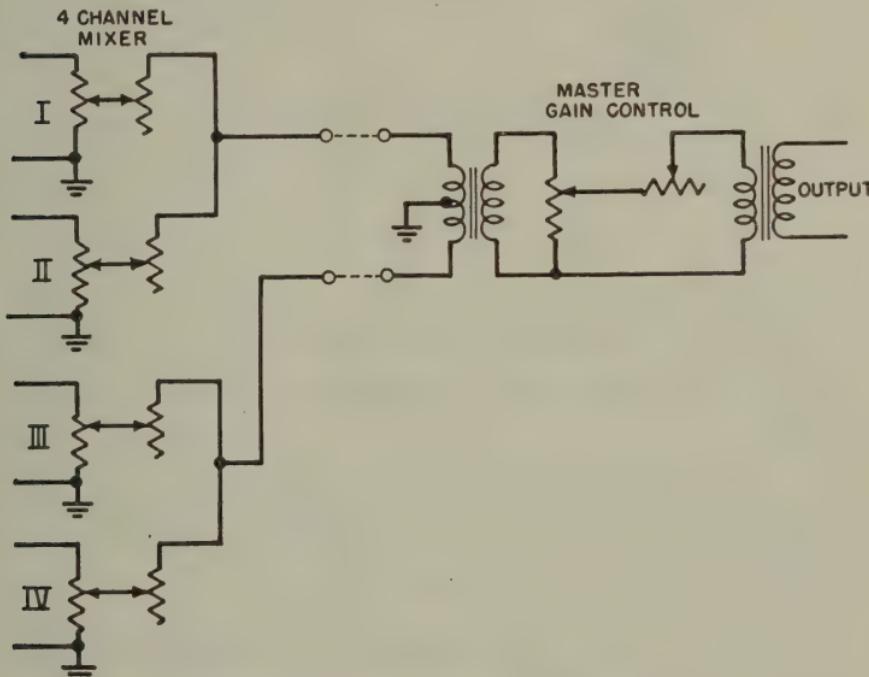


FIG. 4-3.—Four-channel series-parallel mixer.

**Ques. 4.33.** Why is it preferable to isolate the direct current from the primary winding of an audio transformer working out of a single vacuum tube?

**Ans.** To prevent transformer core saturation. A saturated core will lower the primary inductance and seriously

## RADIO OPERATING QUESTIONS AND ANSWERS

impair the quality of transmission. Heavy distortion will occur.

**Ques. 4.34.** Draw a simple diagram of a single-stage triode pre-amplifier employing direct-current isolation of the output transformer primary.

**Ans.** Figure 4-4 illustrates the wiring diagram of a parallel-feeding system for prevention of core saturation.

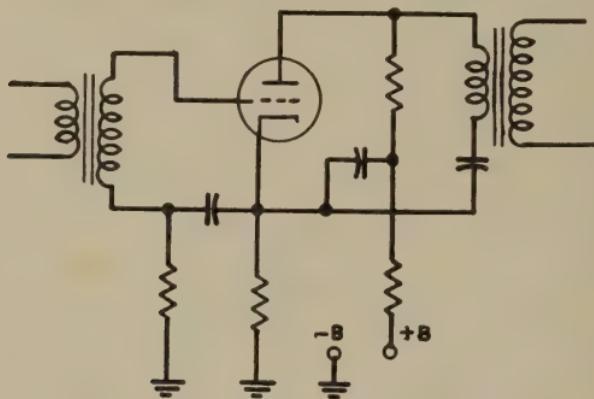


FIG. 4-4.—Parallel-fed amplifier system.

**Ques. 4.35.** Why are pre-amplifiers used ahead of mixing systems?

**Ans.** Mixing systems introduce a signal loss because they are attenuating networks and consequently require a pre-amplifier to compensate for these losses.

**Ques. 4.36.** What is the purpose of a variable attenuator in a speech-input system?

**Ans.** Variable attenuators are used to control the voltage gain of an amplifier. They permit the proper degree of adjustment for variable signal-input levels.

**Ques. 4.37.** In a low-level amplifier using degenerative feedback, at a nominal mid-frequency, what is the phase

**relationship between the feedback voltage and the input voltage?**

*Ans.* Degenerative feedback, or feedback without the generation of sustained oscillations, is that condition in a vacuum-tube amplifying circuit in which energy from the plate circuit to the grid circuit causes the feedback voltage at a nominal mid-band frequency to be 180 degrees out of phase with the input voltage.

**Ques. 4.38.** Under what circumstances will the gain-per-stage be equal to the voltage amplification factor of the vacuum tube employed?

*Ans.* The gain-per-stage in a resistance-coupled amplifier is equal to the voltage amplification factor of the vacuum tube employed. To achieve maximum gain from the tube, the load impedance into which the tube works must be high.

**Ques. 4.39.** Why is a high-level amplifier, feeding a program transmission line, generally isolated from the line by means of a pad?

*Ans.* This is done to prevent overloading the line and also to reduce the possibility of line reflections back to the final stage. Proper impedance relations are also thus maintained.

**Ques. 4.40.** What is the result of deliberately introduced degenerative feedback in audio amplifiers?

*Ans.* This will result in a decrease in the gain of the amplifier, but will greatly improve the frequency characteristic of the amplifier.

**Ques. 4.41.** What unit has been adopted by leading program transmission organizations as a volume unit and to what power is this unit equivalent?

*Ans.* The volume unit or *VU*. It has a power equivalent of 0.001 watt (600 ohms).

**Ques. 4.42. What is meant by "stabilized feedback"?**

*Ans.* "Stabilized feedback" is feedback employed in such a manner as to stabilize the gain of a transmission system or section thereof with respect to time or frequency or to reduce noise or distortion arising therein. (I.R.E. Standards definition, 1938.)

**Ques. 4.43. Why are program circuits, using telephone lines, usually fed in at a level of about 12 milliwatts?**

*Ans.* This level is generally used to prevent overloading of the telephone lines and to reduce output distortion and cross interference with adjacent telephone lines. Telephone repeater amplifiers will be overloaded if this value is exceeded.

**Ques. 4.44. What is the purpose of a line equalizer?**

*Ans.* A line equalizer as used in telephone lines serves to compensate for the higher audio-frequency signal loss through the distributed capacity in the lines. It enables the output of the line to present a "flatter" frequency characteristic.

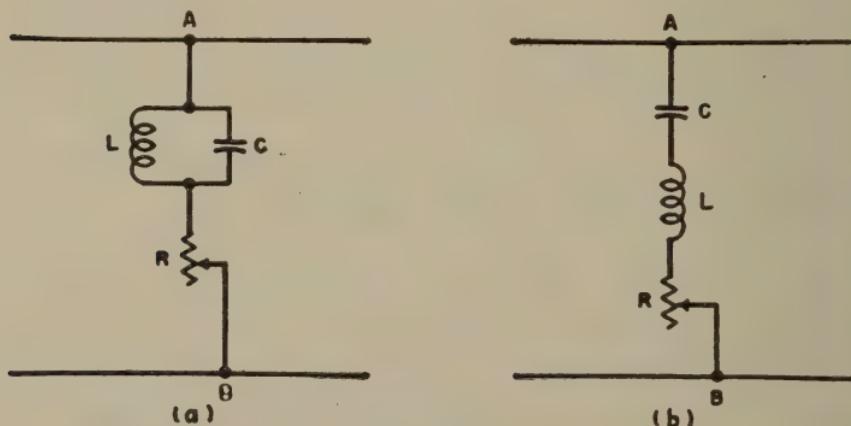


FIG. 4-5.—Line equalizer.

**Ques. 4.45. Draw a diagram of an equalizer circuit most commonly used for equalizing wire-line circuits.**

**Ans.** Figure 4-5 illustrates a telephone-line equalizer.

**Ques. 4.46.** What methods are employed to avoid switching "clicks" in switching operations of mixing circuits?

**Ans.** Switching "clicks" are avoided by maintaining the circuit impedance as constant as possible by switching in substitute impedances when one is removed. Perfect circuit balance and electrostatic shielding will also aid in the prevention of "clicks" or "plops."

**Ques. 4.47.** Why is it generally unnecessary to equalize a short wire-line program circuit?

**Ans.** In a short line the lumped distributed capacity is low enough to make the "shorting effect" negligible on the higher frequencies. Modern telephone practice is to terminate both ends of the usual 600-ohm line in a lower impedance, usually at 150 ohms, when it is desired to improve the frequency response. Mismatching is permissible on very short lines.

**Ques. 4.48.** What will be the result if one side of a properly terminated telephone line becomes grounded?

**Ans.** Line noises, reduced energy transfer, and cross talk may result. Induced and capacity-coupled currents from other circuits will not be balanced out or neutralized.

**Ques. 4.49.** Describe the vertical system of transcription recording. Discuss its advantages and disadvantages.

**Ans.** The vertical system of transcription recording is the basic method used by Edison many years ago. Modulated audio frequencies are transmitted to the pickup head and its associated windings. A vertical armature is placed under the magnetic influence of the windings and the pole pieces in such a manner that electrical impulses received from the amplifier equipment cause an attached stylus or cutting arm to vibrate in accordance with the audio-frequency electrical vibrations. In this system the waves are imposed upon the depths rather than on the walls of the groove as in the case of

lateral recording. The stylus during the recording process follows a vertical movement as it passes over and cuts into a wax disk or record. Some of the outstanding advantages of this type of recording are as follows:

1. Low mechanical impedance.
2. Produces a low degree of record wear.
3. Good high-frequency response.
4. Permits closer groove spacing and, therefore, increased record playing time.
5. Better suited for recording on nonabrasive disks.

**Ques. 4.50.** What type of microphone employs a coil of wire, attached to a diaphragm, which moves in a magnetic field as a result of impinging sound waves?

*Ans.* The dynamic microphone.

**Ques. 4.51.** What is the most serious disadvantage of using carbon microphones with high-fidelity amplifiers?

*Ans.* The possibility of carbon noises or "hissing."

**Ques. 4.52.** Why are the diaphragms of certain types of microphones stretched?

*Ans.* The diaphragms of certain types of microphones are stretched in order to obtain uniform response particularly at the high audio frequencies. The stretching increases the resonant frequency of the diaphragm.

**Ques. 4.53.** Describe the lateral system of transcription recording. Discuss the advantages and disadvantages.

*Ans.* The lateral system of transcription differs essentially from that of the vertical system in that the recording stylus is coupled through a linkage arm to the main mechanical armature. This linkage arm or driving link transmits the pickup energy from the stylus point to a heavier reed armature. In view of this construction the energy is transferred to the walls of the recording groove and is laterally applied.

Hence the name, lateral recording. Some of the advantages of this type of recording system are as follows:

1. Low noise level.
2. Low distortion.
3. Provides excellent recording on lacquer-coated disks.
4. Tracking distortion is greatly reduced.

**Ques. 4.54.** Draw a simple schematic diagram of a grid-bias modulation system, including the modulated radio-frequency stage.

*Ans.* Figure 4-6 illustrates a simple schematic of a grid-bias modulated radio-frequency stage.

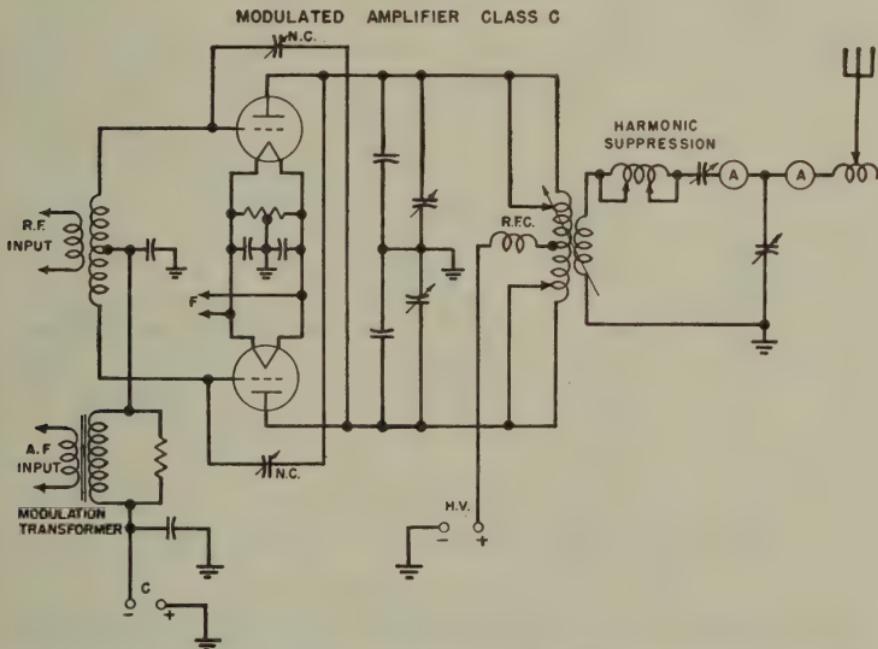


FIG. 4-6.—Grid-bias modulated class C radio-frequency amplifier with inductive coupling to the antenna.

**Ques. 4.55.** Draw a simple schematic diagram of a class B audio high-level modulation system, including the modulated radio-frequency stage.

Ans. Figure 4-7 illustrates a simple schematic of a class B modulated radio-frequency stage.

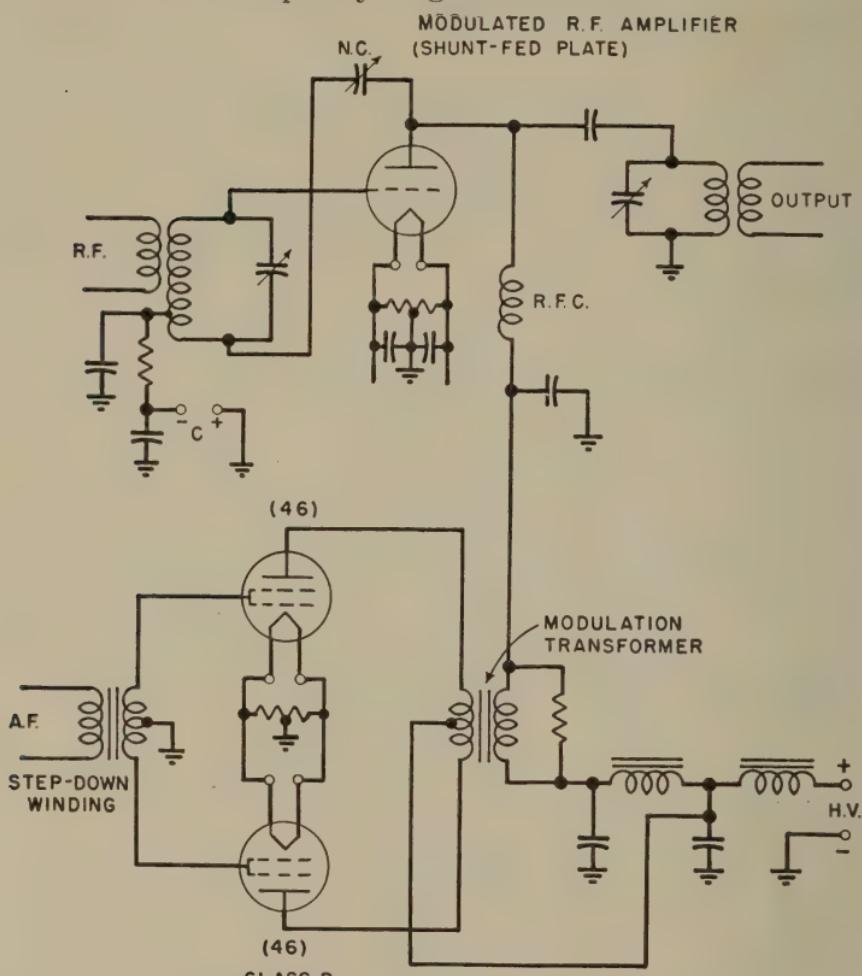


FIG. 4-7.—Class B modulation system.

Ques. 4.56. Draw a simple sketch of the trapezoidal pattern on a cathode-ray oscilloscope screen indicating low per cent modulation without distortion.

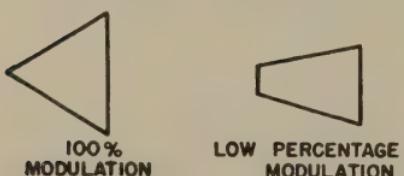


FIG. 4-8.—Cathode-ray trapezoidal pattern.

Ans. Figure 4-8 illustrates a trapezoidal pattern as indicated on the screen of a

cathode-ray tube under the conditions of low percentage of modulation without distortion. The pattern for complete modulation is also shown, for comparison.

**Ques. 4.57.** At 100 per cent modulation, what percentage of the total output power is in the side bands?

**Ans.** At 100 per cent modulation the percentage of total side-band power is equal to 33.3 per cent of the total output power.

**Ques. 4.58.** Draw a schematic diagram of test equipment which may be used to detect carrier-shift of a radiotelephone transmitter output.

**Ans.** Figure 4-9 illustrates an arrangement for determining carrier-shift of a radiotelephone transmitter.

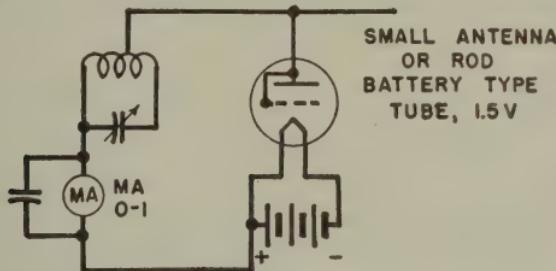


FIG. 4-9.—Simple carrier-shift indicator.

**Ques. 4.59.** To what value is the direct-current grid bias of a grid-bias-modulated amplifier normally adjusted?

**Ans.** The direct-current grid bias is generally adjusted to  $1\frac{1}{2}$  to 4 times the plate-current cut-off value.

**Ques. 4.60.** In radio equipment, what use is made of a fluorescent screen?

**Ans.** The fluorescent screen is used in the cathode-ray tube for observing wave forms. The entire equipment is called a cathode-ray oscilloscope.

**Ques. 4.61. What are the advantages and disadvantages of class B modulators?**

*Ans.* The class B system of modulation provides greater efficiency compared with the distortionless class A system. Class B, however, introduces a relatively greater degree of distortion than the class A system. In addition to the higher plate efficiency the class B modulator provides lower power consumption since plate current flows only during the grid-excitation periods.

**Ques. 4.62. Why is frequency modulation undesirable in the standard broadcast band?**

*Ans.* High-fidelity frequency modulation requires a wider band than amplitude modulation, which would restrict the number of stations operating in this band.

**Ques. 4.63. Describe what is meant by "series modulation."**

*Ans.* "Series modulation" is a form of plate modulation in which the modulated radio-frequency amplifier tube and the modulator tube are connected in series across the direct-current plate supply. That is, the filament center tap of the modulated amplifier tube is connected to the plate of the modulator tube. This system is most commonly used in European broadcast stations.

**Ques. 4.64. What is meant by "low-level" modulation?**

*Ans.* "Low-level modulation" is the term applied to systems in which the modulated radio-frequency stage precedes the final power-amplifier stage.

**Ques. 4.65. If a pre-amplifier, having a 600-ohm output, is connected to a microphone so that the power output is -40 db, and assuming the mixer system to have a loss of 10 db, what must be the voltage amplification necessary in**

the line amplifier in order to feed +10 db into the transmitter line?

*Ans.* The necessary voltage amplification to satisfy these conditions must be 1,000.

*Solution:* (Assuming 600-ohm terminations)

Input is -50 db at 600 ohms.

Output is +10 db at ? ohms.

$$\text{db} = 20 \log \frac{E_1 \sqrt{R_2}}{E_2 \sqrt{R_1}}$$

db gain, therefore, is 60.

$$60 = 20 \log \frac{E_1 \sqrt{600}}{E_2 \sqrt{600}}$$

If

$$\log \frac{E_1}{E_2} = 3,$$

then,

$$\frac{E_1}{E_2} = 1,000.$$

**Ques. 4.66.** If the power output of a modulator is decreased from 1,000 watts to 10 watts, how is the power loss expressed in db?

*Ans.* Gain or loss in db =  $10 \log \frac{P_1}{P_2} = 20$  decibels.

*Solution:*

$$\begin{aligned} 10 \log \frac{P_1}{P_2} \\ = 10 \log 100 \\ \log 100 = 2 \\ \therefore \text{db} = 20. \end{aligned}$$

Since the power has been decreased this is a 20-db loss, or -20 db.

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 4.67.** Under what circumstances will the plate current, as read on a direct-current meter, of a modulated amplifier vary?

*Ans.* The variation of a plate current as indicated on the direct-current meter may be due to excessive radio-frequency drive or overmodulation. This condition may also be caused by an improper load impedance adjustment, improper neutralization, parasitics, insufficient grid bias, a bad tube, or positive or negative carrier shift.

**Ques. 4.68.** What would cause downward deflection of the antenna current of a transmitter when modulation is applied?

*Ans.* Downward deflection during modulation may be due to the following causes: Poor tube, low filament voltage, excessive value of load impedance adjustment, open filter condenser in power supply, improper excitation or negative carrier shift.

**Ques. 4.69.** Under what conditions of operation of a class B linear amplifier will the plate dissipation be a maximum?

*Ans.* The plate dissipation will be a maximum during the period in which the carrier frequency is unmodulated. The plates operate considerably cooler after modulation is applied.

**Ques. 4.70.** If 100 per cent modulation is obtained with an input level of 60 db, what percentage of modulation will be obtained with an input level of 45 db?

*Ans.*

$$\frac{Ndb_1 - Ndb_2}{20} = \frac{60 - 45}{20} = 0.75.$$

$$0.75 = \log \frac{E_1}{E_2}.$$

$$\frac{E_1}{E_2} = 5.62.$$

If at 100 per cent modulation the voltage  $E$  is 100, and these two items decrease in direct proportion, then the voltage

ratio will be,

$$\frac{100}{5.62} = 17.75$$

Modulation percentage = 17.75 per cent.

**Ques. 4.71.** When the light flashes on the panel of the modulation monitor, what is indicated?

*Ans.* This indicates that the modulation peaks are in excess of the peak indicator pre-adjustment value.

**Ques. 4.72.** Why is it desirable to maintain a comparatively high percentage of modulation in a radiotelephone transmitter?

*Ans.* A high percentage of modulation is desirable in radiotelephone transmitters because the audio-frequency peak power is then greatly increased. At 100 per cent modulation the peak power is four times the unmodulated carrier-frequency power. This greatly increases the transmission range of the useful side-band power, and carrier-frequency interference at remote points is correspondingly reduced. The latter is particularly true with low-power transmitters.

**Ques. 4.73.** If tests indicate that the positive modulation peaks are greater than the negative peaks in a transmitter employing a class B audio modulator, what steps should be taken to determine the cause?

*Ans.* Decrease the audio-frequency excitation to ascertain if the excessive positive peaks are caused by a high gain-control setting. Check the balance of the modulator tubes for equality of emission. Check the neutralization of the modulated amplifier. Increase the tank circuit capacity and retune to resonance as an insufficient C will also produce this result. Check the grid-bias adjustments. (See Ques. 6.42.)

**Ques. 4.74.** Under what circumstances will the direct-current plate current, as indicated on a direct-current meter, of a properly adjusted grid-bias modulated radio-frequency amplifier vary?

*Ans.* If all adjustments are assumed to be correct, the plate current as indicated on the direct-current ammeter will vary with excessive audio-frequency excitation (overmodulation).

**Ques. 4.75.** What percentage increase in output power is obtained under 100 per cent sinusoidal modulation?

*Ans.* A 50 per cent increase in output power will be obtained.

**Ques. 4.76.** In a class C radio-frequency amplifier stage feeding an antenna system, if there was a positive shift in carrier under modulation conditions, what could be the trouble?

*Ans.* This may be due to insufficient tank circuit capacity, antenna or tank circuits out of tune, insufficient excitation, improper neutralization or overmodulation. (See Ques. 6.42.)

**Ques. 4.77.** Name four causes of distortion in a modulated-amplifier stage output.

*Ans.* Four causes of distortion in a modulated-amplifier output are:

1. Overmodulation.
2. Excessive radio-frequency drive.
3. Insufficient load impedance adjustment.
4. Improper neutralization (self-oscillation or regeneration) and parasitic oscillations.

**Ques. 4.78.** Under what operating conditions will the efficiency of a grid-bias-modulated radio-frequency amplifier be a maximum?

*Ans.* The efficiency will be maximum during the period in which slight pulses of grid current flow during modulation peaks, that is, during 100 per cent modulation peaks.

**Ques. 4.79.** If the plates of a class B modulator suddenly showed color, without excitation, what could be the cause?

*Ans.* The cause would most probably be self oscillation. It could also be due to an opening in the grid biasing circuit.

**Ques. 4.80.** If you decrease the percentage of modulation from 100 per cent to 50 per cent by what percentage have you decreased the power in the side bands?

*Ans.* The side-band power will be decreased 75 per cent.

*Solution:*

Assuming a 100-watt completely modulated carrier, we get

$$P_{sb} = \frac{m^2 P_c}{2} = \frac{1 \times 100}{2} = 50 \text{ watts.}$$

If modulation is reduced to 50 per cent, we get, by the same formula,

$$\frac{0.5^2 \times 100}{2} = 0.25 \times 50 = 12.5 \text{ watts,}$$

a reduction of 75 per cent.

**Ques. 4.81.** If a certain audio-frequency amplifier has an overall gain of 40 db and the output is 6 watts, what is the input?

*Ans.* The input will be 0.0006 watt or 0.6 milliwatt.

*Solution:*

$$db = 10 \log \frac{P_1}{P_2}; 40 = 10 \log \frac{6}{x}; 10,000 = \frac{6}{x}$$

$$x = \frac{6}{10,000} = 0.0006.$$

**Ques. 4.82.** What is the purpose of a Faraday or electrostatic shield between the final tank circuit and the antenna circuit of a transmitter?

*Ans.* A Faraday screen reduces the coupling electrostatically between the two circuits and makes the coupling more purely magnetic. This will reduce the radiation of harmonics since harmonics are mostly coupled through inter-winding capacitance.

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 4.83.** If the field intensity of 25 millivolts per meter develops 2.7 volts in a certain antenna, what is the effective height?

*Ans.* The effective height will be 108 meters.

*Proof:* A height of 1 meter will develop 0.025 volt

**Ques. 4.84.** Draw a schematic diagram of a final amplifier with capacity coupling to the antenna which will discriminate against the transfer of harmonics.

*Ans.* Figure 4-10 illustrates a capacitive coupling system.

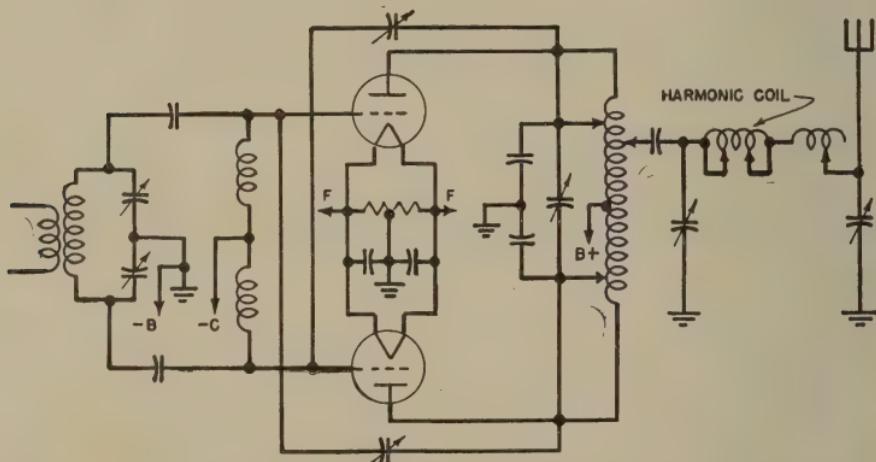


FIG. 4-10.—Capacitive coupling and harmonic suppression arrangement.

**Ques. 4.85.** In what units is the field intensity of a broadcast station normally measured?

*Ans.* Field intensity is generally measured in millivolts or microvolts per meter.

**Ques. 4.86.** Draw a simple schematic diagram showing a method of coupling the radio-frequency output of the final power-amplifier stage of a transmitter to a two-wire transmission line, with a method of suppression of second- and third-harmonic energy.

**Ans.** Figure 4-11 illustrates a schematic arrangement of a final power-amplifier stage with transmission-line coupling and harmonic-suppression circuit.

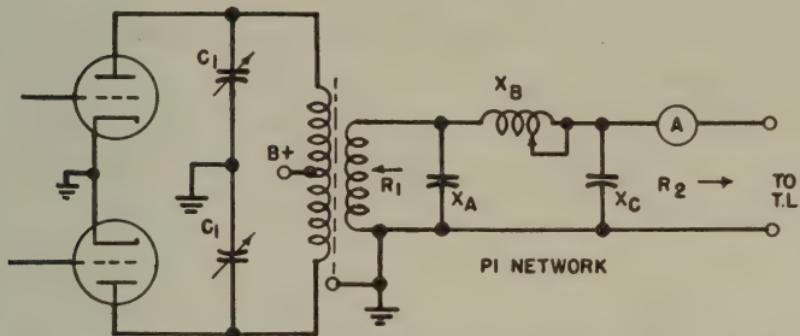


FIG. 4-11.—Transmission-line coupling system.

**Ques. 4.87.** Describe a method of determining antenna resistance.

**Ans.** Figure 4.12 illustrates the circuit arrangements of the apparatus used for measuring antenna resistance.

The measurement is based on the formula

$$R = \frac{R_1}{\frac{I}{I_1} - 1},$$

where  $R$  = resistance of the antenna.

$R_1$  = the added resistance.

$I$  = the current reading without added resistance.

$I_1$  = the current reading with added resistance.

To make the measurement proceed as follows:

1. Antenna circuit should be adjusted for operating conditions. Radiation ammeter may be left in the circuit.
2. Take out all  $R_1$  resistance by closing the short-circuiting switch.
3. Start driver and tune it to resonance with antenna circuit.

4. Record current reading on radio-frequency milliammeter. This becomes the  $I$  value in the formula.

5. Do not vary power in driver. Insert a value of  $R_1$ , say, 2 ohms.

6. Record current reading on radio-frequency milliammeter. This becomes the  $I_1$  value in the formula.

The above procedure may be repeated with four or five different values of  $R_1$  and the value of  $R$  averaged. Accurate results are more likely to be obtained in this way.

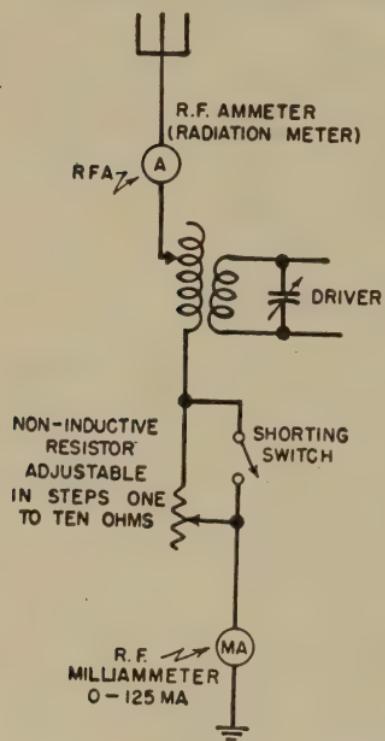


FIG. 4-12.—Circuit for measuring antenna resistance.

A 50-watt tube operating at a reduced input power should be used to insure the greatest degree of accuracy when using loose coupling between the driver and the pick-up coil.

The above-described method is commonly known as the "resistance-variation system" for measuring the antenna resistance and is generally accepted as a very accurate and simple procedure.

The input power can thus be determined by multiplying the antenna current reading at the maximum current point by the resistance  $R$  using the formula  $I^2R$ .

The above method does not, however, determine the actual amount of radiated power from an antenna, since this can only be obtained by field strength measurements at various points at a distance from the radiating system.

**Ques. 4.88.** An antenna is being fed by a properly terminated two-wire transmission line. The current in the line at the output end is 3 amperes. The surge impedance of the line is 500 ohms. How much power is being supplied to the line?

*Ans.*  $P = I^2R = 9 \times 500 = 4,500$  watts

**Ques. 4.89.** If the daytime transmission-line current of a 10-kilowatt transmitter is 12 amperes, and the transmitter is required to reduce to 5 kilowatts at sunset, what is the new value of transmission-line current?

*Ans.* The new value of current is 8.4 amperes.

*Solution:*

$$R = \frac{P}{I^2} = \frac{10,000}{144} = 70 \text{ ohms.}$$

$$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{5,000}{70}} = 8.4 \text{ amperes.}$$

**Ques. 4.90.** If the antenna current is 9.7 amperes for 5 kilowatts, what is the current necessary for a power of 1 kilowatt?

*Ans.* For a power of 1 kilowatt the current necessary will be 4.3 amperes, computed as in the preceding answer.

**Ques. 4.91.** What is the antenna current when a transmitter is delivering 900 watts into an antenna having a resistance of 16 ohms?

*Ans.*

$$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{900}{16}} = 7.5 \text{ amperes.}$$

**Ques. 4.92.** If the day input power to a certain broadcast station antenna having a resistance of 20 ohms is 2,000 watts, what would be the night input power if the antenna current were cut in half?

*Ans.* The night input power would be 500 watts.

*Solution:*

$$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{2,000}{20}} = \sqrt{100} = 10 \text{ amperes.}$$

$$\frac{10}{0.5} = 5 \text{ amperes.}$$

$$P = I^2R = 25 \times 20 = 500 \text{ watts.}$$

**Ques. 4.93.** The direct-current input power to the final-amplifier stage is exactly 1,500 volts and 700 milliamperes. The antenna resistance is 8.2 ohms and the antenna current is 9 amperes. What is the plate efficiency of the final amplifier?

*Ans.* The plate efficiency is 63.25 per cent.

*Solution:*

$$\text{Efficiency} = \frac{P_o}{P_i} = \frac{664.2}{1,050} = 0.6325 \text{ or } 63.25 \text{ per cent.}$$

**Ques. 4.94.** If the power output of a broadcast station is quadrupled, what effect will this have upon the field intensity at a given point?

*Ans.* The field intensity at a given point will be doubled.

*Solution:* An increase of power to 4 times will result in a current increase of 2 times. The field intensity, therefore, will increase in direct proportion.

**Ques. 4.95.** The ammeter connected at the base of a Marconi antenna has a certain reading. If this reading is increased 2.77 times, what is the increase in output power?

*Ans.* The increase in output power will be 7.67 times greater.

*Solution:*

$$P = I^2R \text{ watts.}$$

If the current is increased by 2.77 times then the power must increase  $2.77^2$  times.

**Ques. 4.96.** If the power of a broadcast station has been increased so that the field intensity at a given point is doubled, what increase has taken place in the antenna current?

*Ans.* The antenna current under these conditions has been doubled.

*Solution:* Field power is proportional to antenna power which is proportional to antenna current squared. Field power is also proportional to field intensity squared. Therefore, field intensity is proportional to antenna current. If the field intensity is doubled, the antenna current was also doubled.

**Ques. 4.97.** If a transmitter is modulated 100 per cent by sinusoidal tone, what percentage increase in antenna current will occur?

*Ans.* The antenna current will increase 1.225 times the unmodulated current or 22.5 per cent.

*Solution:*

$$I_{eff} = \sqrt{1 + \frac{m^2}{2}}.$$

$$\text{At 100 per cent } I_{eff} = \sqrt{1.5} = 1.225.$$

**Ques. 4.98.** What relationship obtains between the currents at the opposite ends of a transmission line,  $\frac{1}{4}$  wavelength

long, and terminated in an impedance equal to its surge impedance?

*Ans.* The current readings at the input and output ends of the line will be equal.

**Ques. 4.99.** The power input to a 72-ohm concentric transmission line is 5,000 watts. What is the peak voltage between the inner conductor and the sheath?

*Ans.* The peak voltage is 848.4 volts.

*Solution:*

$$E = \sqrt{PR} = \sqrt{5,000 \times 72} = \sqrt{360,000} = 600.$$
$$E_{peak} = E_{eff.} \times 1.414 = 848.4 \text{ volts.}$$

**Ques. 4.100.** A long transmission line delivers 10 kilowatts into an antenna; at the transmitter end the line current is 5 amperes and at the coupling house it is 4.8 amperes. Assuming the line current to be properly terminated and the losses in the coupling system negligible, what is the power lost in the line?

*Ans.* The power lost in the line is 850 watts.

*Solution:*

$$R = \frac{P}{I^2} = \frac{10,000}{4.8^2} = 434.$$

$$\text{Power lost} = 5^2 \times 434 - 10,000 = 850 \text{ watts.}$$

**Ques. 4.101.** The power input to a 72-ohm concentric line is 5,000 watts. What is the current flowing in it?

*Ans.* The current flow is 8.35 amperes.

*Solution:*

$$I = \sqrt{\frac{P}{R}} = 8.35 \text{ amperes.}$$

**Ques. 4.102.** What is the primary reason for terminating a transmission line in an impedance equal to the characteristic impedance of the line?

*Ans.* Proper termination of a transmission line prevents standing waves and resultant line radiations. A maximum transfer of power to the radiating system also results. Harmonic radiation is minimized.

**Ques. 4.103.** In general, what type of antenna is the most suitable for broadcast stations?

*Ans.* The vertical type is the most suitable. This is generally of the half-wave type, shunt-fed.

**Ques. 4.104.** If a vertical antenna has a resistance of 500 ohms and a reactance of zero at its base and an antenna power input of 10 kilowatts, what is the peak voltage to ground under 100 per cent modulation conditions?

*Ans.* The peak voltage at 100 per cent modulation will be 6,325 volts.

Since  $P = E^2 \div R$ ,  $E = \sqrt{PR}$ . Also, since the unmodulated power is given as 10,000 watts and since the modulated power is four times this unmodulated value or 40,000 watts,  $E$  at 100 per cent modulation is,

$$\text{Effective } E_{mod} = \sqrt{40,000 \times 500} = \sqrt{20,000,000} = 4,473 \text{ volts.}$$

$$\text{Peak } E_{mod} = 4,473 \times 1.414 = 6,325 \text{ volts.}$$

**Ques. 4.105.** If a vertical antenna is 405 feet high and is operated at 1,250 kilocycles, what is its physical height, expressed in wavelengths? (1 meter = 3.28 feet.)

*Ans.* The physical wavelength is 0.515 wavelength.

**Ques. 4.106.** What must be the height of a vertical radiator  $\frac{1}{2}$  wavelength high if the operating frequency is 1,100 kilocycles?

*Ans.* The height must be 136.2 meters.

**Ques. 4.107.** Draw a diagram of a crystal oscillator, including temperature control, with one stage of radio-frequency amplification. Power supplies need not be shown but indicate points at which the various voltages will be connected.

**Ans.** Figure 4-13 illustrates a crystal oscillator with temperature-control chamber coupled to one stage of radio-frequency amplification.

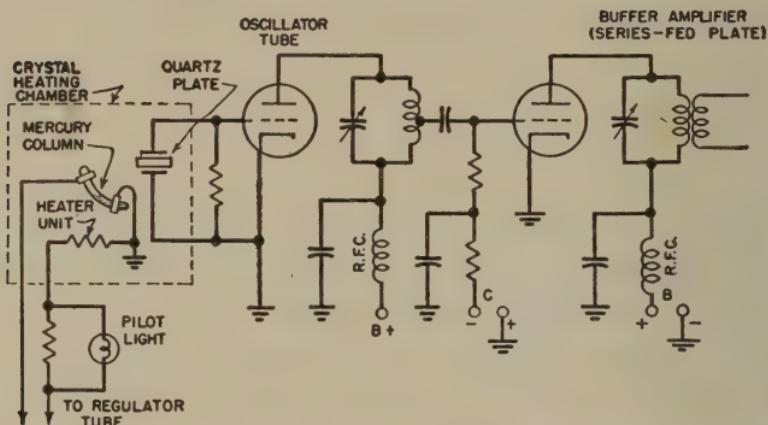


FIG. 4-13.—Crystal-controlled oscillator with temperature-control unit and radio-frequency amplifier.

**Ques. 4.108.** Draw a diagram of a class B push-pull linear amplifier using triode tubes. Include a complete antenna coupling circuit and antenna circuit. Indicate points at which the various voltages will be connected.

**Ans.** Figure 4-10 illustrates a class B linear amplifier in push-pull arrangement coupled to an antenna system.

**Ques. 4.109.** Draw a diagram of a complete class B modulation system, including the modulated radio-frequency amplifier stage. Indicate points where the various voltages will be connected.

*Ans.* Figure 4-7 illustrates a class B modulation system and modulated radio-frequency amplifier.

**Ques. 4.110.** Draw a simple longitudinal cross-section of a water-cooled transmitting triode, showing the internal structure and labeling the various elements.

*Ans.* Figure 4-14 illustrates a longitudinal cross-section of a water-cooled transmitting triode.

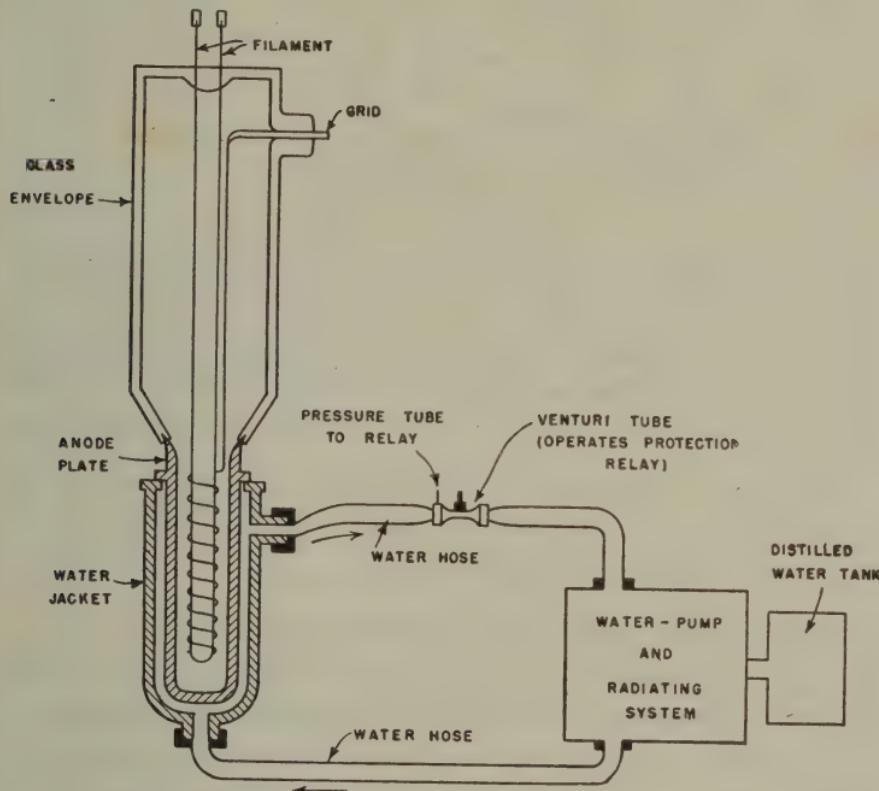


FIG. 4-14.—Water-cooled tube with water-circulating system.

**Ques. 4.111.** Show by diagram where the plate ammeter should be connected in a water-cooled triode radio-frequency amplifier with parallel feed in order to exclude the measurement of the current leakage in the water column.

Ans. Figure 4-15 illustrates the proper connection of a plate ammeter in a water-cooled radio-frequency amplifier.

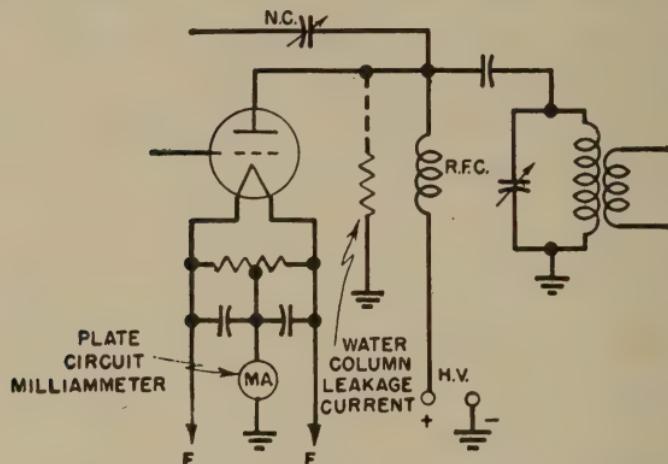


FIG. 4-15.—Correct ammeter connection in water-cooled system.

**Ques. 4.112.** What frequencies are present in the output wave of a transmitter operating on a carrier frequency of 1,100 kilocycles and being modulated by a 400-cycle sinusoidal tone.

*Ans.* The upper and lower side-band frequencies of 1,100.4 kilocycles and 1,099.6 kilocycles, respectively, and the carrier frequency of 1,100 kilocycles.

**Ques. 4.113. What is a “dummy antenna”?**

*Ans.* A "dummy antenna" as used in transmission systems constitutes a non-reactive heat-dissipating resistance equal in value to the antenna resistance itself. It serves as a matched load in place of the antenna system to facilitate circuit tuning and transmission-line adjustments.

Ques. 4.114. Why are the tubes in the final radio-frequency stages of a transmitter not generally operated as class A?

*Ans.* The low efficiency of a final-stage class A amplifier would require relatively larger tubes and would result in poor

economy. The distortionless efficiency of a class A amplifier for broadcast purposes is approximately 25 per cent. Class B and C amplifiers operate with considerably more efficiency, 35 to 65 per cent.

**Ques. 4.115.** A certain transmitter has an output of 100 watts. The efficiency of the final, modulated-amplifier stage is 50 per cent. Assuming that the modulator has an efficiency of 66 per cent, what plate input to the modulator is necessary for 100 per cent modulation of this transmitter?

*Ans.* The plate input power to the modulator is 151.5 watts. On the basis of 100-watt carrier requirements and an efficiency of 50 per cent the modulated amplifier must have an input power of 200 watts. At 100 per cent modulation the total of the load power and the plate dissipation will be increased by 50 per cent. Hence the modulator must supply 100 watts of audio-frequency power and, since it is operating at an efficiency of 66 per cent, the power input to the modulator must be 151.5 watts.

*Solution:*

$$\frac{P_o}{Eff} = \frac{100}{0.66} = 151.5 \text{ watts}$$

where  $P_o$  is the power output required and  $Eff$  the efficiency.

**Ques. 4.116.** If an oscillatory circuit consists of two identical tubes, the grids of which are connected in push-pull and the plates in parallel, what relationship will hold between the input and output frequencies?

*Ans.* This arrangement may be used as a frequency-doubling system provided that the plate circuit is tuned to twice the input frequency.

**Ques. 4.117.** Why are series resistors sometimes used in grid circuits of radio-frequency amplifiers?

*Ans.* They are used to prevent parasitic oscillations.

**Ques. 4.118. What may cause parasitic oscillations?**

*Ans.* Parasitic oscillations are spurious oscillations set up in a radio-frequency amplifier by stray lead capacities and inductances. This condition generally prevails when tubes are connected in parallel or push-pull owing to their connecting leads although other conditions may also cause parasitics.

**Ques. 4.119. What undesirable effects result from over-modulation of a broadcast transmitter?**

*Ans.* Overmodulation may cause serious interference on adjacent channels to which the transmitter in question is operating. Overmodulation also causes distortion.

**Ques. 4.120. What do variations in the final amplifier plate current of a transmitter employing low-level modulation usually indicate?**

*Ans.* Excessive radio-frequency drive, excessive modulation, or improperly tuned tank circuit.

**Ques. 4.121. If, upon tuning the plate circuit of a triode radio-frequency amplifier, the grid current undergoes variations, what defect is indicated?**

*Ans.* This may be indicative of too much radio-frequency drive or improper grid-bias selection. It may also indicate improper neutralization and the presence of self-oscillation or even parasitic oscillations.

**Ques. 4.122. The 50-kilowatt output stage of a broadcast transmitter, having a final amplifier efficiency of 33 per cent, has a plate current of 10 amperes. If the water-cooling system leakage-current meter reads 11 milliamperes, what is the resistance of the water system from plate to ground?**

*Ans.* The resistance is 1,377,272 ohms or 1.38 megohms.

*Solution:*

$$\text{Operating Power} = E \times I \times \text{Efficiency}.$$

Hence,  $50,000 = E \times 10 \times 0.33$  and  $E \times 3.3 = 50,000$ .

Then  $E = 50,000 \div 3.3 = 15,150$  volts, and

$$R = \frac{E}{I} = \frac{15,150}{0.011} = 1,377,272 \text{ ohms or } 1.38 \text{ megohms.}$$

**Ques. 4.123.** If the final amplifier grid-bias supply suddenly becomes short-circuited in a regular broadcast transmitter installation, what will likely result?

*Ans.* Removal of the grid bias from the final power-amplifier grids will cause a sudden high rise in plate current which will trip the overload relay. The plate voltage supply will be automatically disconnected, thereby preventing damage to the tubes.

**Ques. 4.124.** What fire-extinguishing agent will subject station personnel to least danger from shock and cause a minimum of damage to electrical equipment?

*Ans.* Carbon dioxide.

**Ques. 4.125.** What is the primary reason for using chemically pure water in the water-cooling system of high-power transmitters?

*Ans.* Chemically pure water has a high dielectric constant and, therefore, serves as a splendid insulating medium. Impure water containing metallic deposits or saline components may introduce excessive anode leakage or short circuits.

**Ques. 4.126.** A 50-kilowatt transmitter employs 6 tubes in push-pull parallel in the final class B linear stage, operating

## RADIO OPERATING QUESTIONS AND ANSWERS

with a 50-kilowatt output and an efficiency of 33 per cent. Assuming that all of the heat radiation is to the water-cooling system, what amount of power must be dissipated from each tube?

*Ans.* The power input to all of the tubes is

$$\frac{P_o}{Eff} = \frac{50,000}{0.33} = 151,515 \text{ watts}; \quad P_i - P_o = 101,515 \text{ watts.}$$

Each tube will therefore dissipate 16,919 watts.

**Ques. 4.127.** Draw a simple schematic diagram of the water-cooling system of a high-power broadcast station. Assume only one water-cooled stage. Indicate direction of water flow and parts of the system.

*Ans.* Figure 4-14 illustrates how a single-stage water-cooled radio-frequency power amplifier should be connected and direction of water flow.

**Ques. 4.128.** What is the value of voltage drop across the elements of a mercury-vapor rectifier tube under normal conditions?

*Ans.* The normal voltage drop across a mercury-vapor rectifier tube is 15 volts.

**Ques. 4.129.** Draw a diagram of a bridge rectifier giving full-wave rectification without a center-tapped transformer. Indicate polarity of output terminals.

*Ans.* Figure 2-39 illustrates a full-wave bridge-rectifier arrangement.

**Ques. 4.130.** Draw a diagram of a rectifier system supplying two plate voltages, one approximately twice the other and using one high-voltage transformer with a single center-tapped secondary, and such filament supplies as may be necessary.

*Ans.* Figure 4-16 illustrates a full-wave bridge rectifier for double voltage supply.

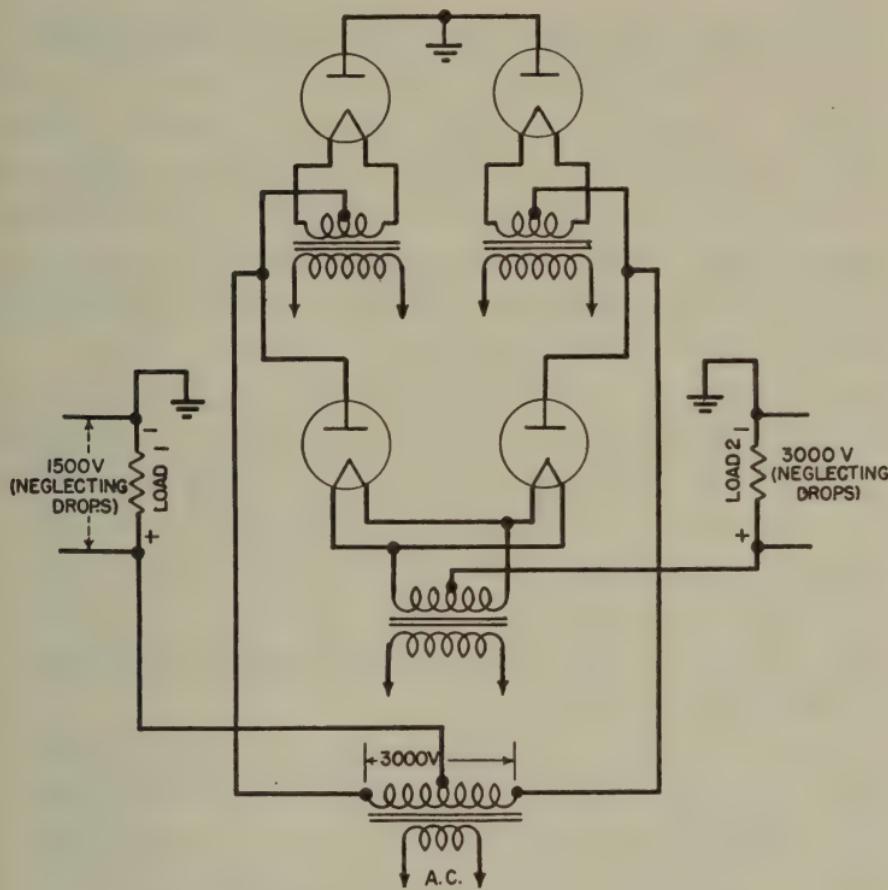


FIG. 4-16.—Balanced single-phase full-wave rectifier.

**Ques. 4.131.** What is "arc back" or "flash back"?

*Ans.* "Flash back" or "arc back" is a condition in mercury-vapor rectifier circuits in which the rectifier tube is ionized to the point of conduction in the reverse direction. For mercury-vapor tubes there is a critical voltage above which this will occur. Under normal conditions arc back may suddenly occur, caused by the input condenser discharging back through the tube, or by radio-frequency reactions from the operating circuit. Under such conditions the tube filament will be

subjected to abnormal ion bombardment and the tube may be ruined.

**Ques. 4.132.** What is meant by the "inverse peak voltage" rating of a rectifier tube?

*Ans.* "Inverse peak voltage" is the maximum potential difference which exists between the plate and cathode of a tube during that period of the cycle when the tube is not conducting.

**Ques. 4.133.** What is the principal disadvantage in the use of a dynamotor, rather than a motor generator, to furnish power to a small mobile transmitter?

*Ans.* The main disadvantage of the dynamotor as compared to a motor generator is that it possesses a common field for both motor and generator sections. This makes it difficult to obtain variable voltage outputs without affecting the speed, and conversely, to obtain a steady voltage output under fluctuating speed conditions.

**Ques. 4.134.** How may the output voltage of a dynamotor be regulated?

*Ans.* The output voltage of a dynamotor may be regulated by a variable line resistor in series with the generator winding. The voltage output may also be regulated by controlling the input current, but the load-voltage regulation would be affected.

**Ques. 4.135.** If a 15-horsepower 220-volt single-phase alternating-current motor is 92 per cent efficient when delivering its full rated output, what is the input current at a power factor of 0.85?

*Ans.*

1 horsepower = 746 watts.

$$\text{Efficiency} = 100 \times \frac{P_o}{P_i} = \frac{\text{power output}}{\text{power input}} = 92 \text{ per cent.}$$

$$I = \frac{P_i}{\text{p.f.} \times E} = 65 \text{ amperes (approx.)}$$

**Ques. 4.136.** How may a condenser be added to a choke-input filter system to increase the load-voltage output?

*Ans.* Voltage may be raised by adding an input-filter condenser before the choke coil, but the system is then changed to the condenser-input type.

**Ques. 4.137.** Why is it not advisable to operate a filter reactance in excess of its rated current value?

*Ans.* An excessive current flow through a filter reactance may increase the possibility of core saturation and additional *IR* drop. Both conditions would affect the output regulation as well as the filtering. The inductance of any iron core reactor will drop as the core becomes saturated.

**Ques. 4.138.** What is a low-pass filter?

*Ans.* The low-pass filter is used in any circuit where it is desired to attenuate all frequencies above a definite cut-off frequency and to pass without attenuation all frequencies below this point.

**Ques. 4.139.** Draw a diagram of a simple low-pass filter.

*Ans.* See Fig. 4-17. The high-pass filter is also shown, for comparison.

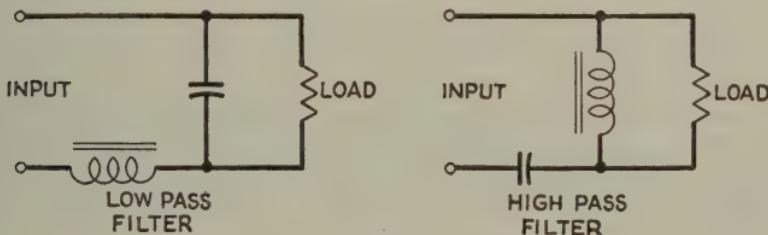


FIG. 4-17.—Filter networks.

**Ques. 4.140.** If a power supply has a regulation of 11 per cent when the output voltage at full load is 240 volts, what is the output voltage at no load?

*Ans.* The no-load output voltage is 266.4 volts.

*Solution:*

$$E_{NL} = 240 \times 1.11 = 266.4 \text{ volts.}$$

*Proof:*

$$\frac{E_{NL} - 240}{E_{FL}} = 0.108 \text{ or } 11 \text{ per cent.}$$

**Ques. 4.141.** How is the inverse-peak voltage, to which the tubes of a full-wave rectifier will be subject, determined from the known secondary voltages of the power transformer? Explain.

*Ans.* The inverse-peak voltage is obtained by multiplying the known effective end-to-end secondary alternating-current voltage by 1.414 and subtracting the drop in the idle tube.

**Ques. 4.142.** If a power supply has an output voltage of 140 volts at no load and the regulation at full load is 15 per cent, what is the output voltage at full load?

*Ans.* The output voltage at full-load conditions is 121.7 volts.

*Solution:*

$$140 \div 1.15 = 121.7.$$

**Ques. 4.143.** If the secondary of the high-voltage transformer in one phase of a three-phase rectifier system became defective, how could operation be continued until repairs could be made?

*Ans.* Assuming that the three-phase system is the standard broadcast type of full-wave rectification, and a spare high-voltage single-phase transformer is not available, then it is

possible to operate the three-phase system with a power reduction, as shown in Fig. 4-18. Disconnect defective coil.

**Ques. 4.144.** Why is a time-delay relay arranged to apply the high voltage to the anodes of mercury-vapor rectifier tubes some time after the application of filament voltage?

*Ans.* The time-delay relay prevents the application of high plate voltages to the rectifier until the filament has been sufficiently heated. The preheating period in mercury-vapor tubes prevents the heavy overloading condition which would exist if the plate voltage were to be applied before the filament is up to proper temperature. Another reason for preheating before applying the plate voltage on mercury-vapor tubes is to vaporize the mercury deposits upon the filament caused by the condensation which takes place when they are not in use.

**Ques. 4.145.** Why is it important to maintain the operating temperature of mercury-vapor tubes within specified limits?

*Ans.* Excessive filament voltage produces increased ionization and reduces the tube life while insufficient filament voltages produce severe overloading and possible burn out.

**Ques. 4.146.** If a frequency-doubler stage has an input frequency of 1,000 kilocycles, and the plate inductance is 60 microhenrys, what value of plate capacitance is necessary for resonance, neglecting stray capacitances?

*Ans.* If the input frequency of a doubler system is 1,000 kilocycles, the output circuit must be tuned to 2,000 kilocycles. Hence, the capacity required would be 105 micro-microfarads. Computed according to the formula

$$C = \frac{1}{4\pi^2 f^2 L} \text{ farads.}$$

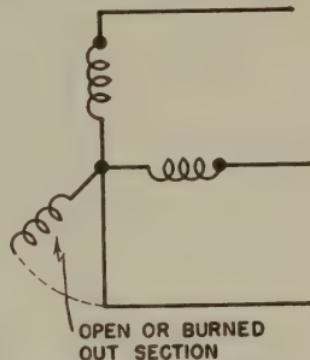


FIG. 4-18.—Emergency connections for a defective three-phase transformer.

**Ques. 4.147.** Draw a simple schematic diagram of a multivibrator oscillatory circuit.

*Ans.* Figure 4-19 illustrates a simple schematic of a multivibrator circuit.

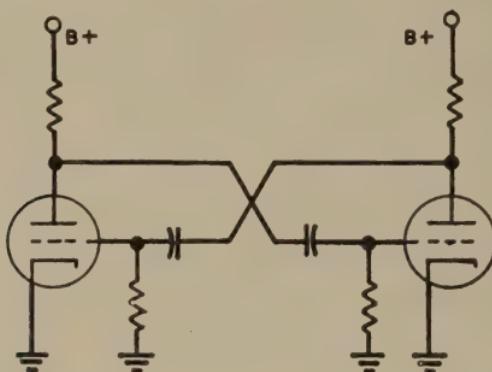


FIG. 4-19.—Multivibrator oscillator.

**Ques. 4.148.** What precautions should be taken to insure that a crystal oscillator will function at one frequency only?

*Ans.*

1. The temperature must be kept constant.
2. The crystal mounting must be proper and maintain correct pressure.
3. The crystal must be accurately ground.
4. The crystal must be perfectly clean, although coatings are sometimes used to deliberately change the frequency.
5. The power-supply voltage must be kept constant.
6. The load must be kept constant by use of a buffer amplifier.

**Ques. 4.149.** What are the advantages of mercury thermostats as compared with bimetallic thermostats.

*Ans.* Mercury thermostats insure better electrical contacts.

**Ques. 4.150.** A 600-kilocycle X-cut crystal, calibrated at 50 degrees centigrade, and having a temperature coefficient of -20 parts per million per degree, will oscillate at what frequency when its temperature is 60 degrees centigrade?

*Ans.* 599,880 cycles.

**Ques. 4.151.** Why are crystals usually operated in temperature-controlled ovens?

*Ans.* Crystals are usually operated in temperature-controlled ovens because they possess a temperature coefficient. A change in temperature will produce a change in frequency. A fixed value of temperature will hold the crystal at a precise frequency.

**Ques. 4.152.** What is the device called which is used to derive a standard frequency of 10 kilocycles from a standard-frequency oscillator operating on 100 kilocycles?

*Ans.* The device is called a multi-vibrator.

**Ques. 4.153.** What procedure should be adopted if it is found necessary to replace a tube in a heterodyne frequency meter?

*Ans.* The frequency meter must be rechecked against a standard calibrator for zero beats in accordance with the exact frequency calibrations. If a standard calibrator is not available, the plate currents and filament voltages of the replaced tubes should be carefully checked as compared with the previous readings, and any necessary voltage and current changes made so that the old and new readings correspond.

**Ques. 4.154.** Why is it necessary to employ pure direct current for the plate supply of a heterodyne frequency meter?

*Ans.* Pure direct-current power-supply systems are required for heterodyne frequency meters to insure a maximum frequency stability.

**Ques. 4.155.** What are "Lissajous figures"?

*Ans.* "Lissajous figures" are encountered in electron stream meters or cathode-ray tubes. The cathode-ray tube is so constructed that a stream of electrons emitted from a hot

cathode is projected through two pairs of plates. Now, if an alternating voltage is applied to one pair of plates, the stream of electrons is deflected back and forth between the plates, and the spot of light upon the fluorescent screen is stretched out into a line symmetrically disposed about the spot. If an alternating voltage is applied to the other pair of plates, a line at right angles to the first will be produced. If the two signals are applied simultaneously, the spot will trace a path on the screen which is the resultant of the two components. The result is a closed pattern which appears stationary when the frequencies of the applied signals bear an harmonic relationship to each other. For two frequencies of equal magnitude the pattern reproduced will vary from a straight line to a circle. A change in phase of the two voltages will change the figure pattern. For example, if the voltages are of sinusoidal character and of the same frequency, of equal magnitude and in phase, the pattern is a straight line making a 45-degree angle with the horizontal. If, now, the phase of one voltage is changed, the pattern becomes an ellipse which gradually widens as the phase angle is increased, until it finally resembles a circle, or 90 degrees. Lissajous figures are, therefore, convenient patterns for analyzing phase shifts and displacements.

**Ques. 4.156.** If a frequency of 500 cycles is beat with a frequency of 550 kilocycles, what will be the resultant frequencies?

*Ans.* The resultant frequencies are  $f_m$ ,  $f_o$ ,  $f_1$ , and  $f_2$  or 500 cycles, 550, 550.5 and 549.5 kilocycles, respectively.

**Ques. 4.157.** In what part of a broadcast-station system are phase monitors sometimes found? What is the function of this instrument?

*Ans.* Phase monitors are sometimes found in transmission systems where two or more directive transmission-line

antennas are employed. This is generally known as the Adcock principle and operates through the use of two or more vertical radiators excited from a common source but in such a manner that the two vertical antennas receive voltages 180 degrees out of phase with each other, so that the current flowing in each vertical antenna is in an opposite direction to that of the other antenna. This system is particularly applicable to cases in which energy is to be transmitted in the vertical plane only. The actual amount of phase departure between antennas may be accurately determined by a meter or so-called "phase monitor" which reads the actual angular variation in degrees. A mutual-inductance bridge such as is sometimes used in line amplifiers for determining the phase shift on an artificial line or filter system may also be called a phase monitor although this is more aptly called a phase-measuring device.

**Ques. 4.158.** If a broadcast station receives a frequency-measurement report indicating that the station frequency was 45 cycles low at a certain time, and the transmitter log for the same time shows the measured frequency to be 5 cycles high, what is the error in the station-frequency monitor?

*Ans.* The error in the reading of the station frequency meter is 50 cycles.

**Ques. 4.159.** If a heterodyne-frequency meter, having a straight-line relation between frequency and dial reading, has a dial reading of 31.7 for a frequency of 1,390 kilocycles, and a dial reading of 44.5 for a frequency of 1,400 kilocycles, what is the frequency of the ninth harmonic of the frequency corresponding to a scale reading of 41.2?

*Ans.* The frequency of the ninth harmonic of the frequency corresponding to a scale reading of 41.2 is 12,576 kilocycles.

**Ques. 4.160.** What is the reason why certain broadcast-station frequency monitors must receive their energy from an unmodulated stage of the transmitter?

*Ans.* To insure that the frequency monitor shall not be affected by side band frequencies.

**Ques. 4.161.** In what part of a broadcast-station system are limiting devices usually employed?

*Ans.* Limiting devices are used at the transmitter end of a broadcast-station system in conjunction with the speech-input equipment to the transmitter.

**Ques. 4.162.** What are the results of using an audio-peak limiter?

*Ans.* Audio-peak limiters prevent the modulation percentage of the transmitter from being exceeded. They are adjusted so that any degree of modulation peaks may be supplied to the transmitter and will not allow the percentage of modulation to exceed the preadjusted value regardless of the peak amplitude of the incoming audio-frequency wave.

**Ques. 4.163.** How is the load on a modulator, which modulates the plate circuit of a class C radio-frequency stage, determined?

*Ans.* (See Ques. 4.115.)

**Ques. 4.164.** Given a class C amplifier with a plate voltage of 1,000 volts and a plate current of 150 milliamperes which is to be modulated by a class A amplifier with a plate voltage of 2,000 volts, plate current of 200 milliamperes, and a plate impedance of 15,000 ohms. What is the proper turns ratio for the coupling transformer?

*Ans.* The calculation of the turns ratio for the coupling transformer is based upon the assumption that a class A amplifier for distortionless power output must work into a

load impedance of twice the alternating-current plate resistance  $R_p$ .

Class A tube,

$$15,000 \text{ ohms} = R_p \quad \therefore 2R_p = 30,000 \text{ ohms} = Z_1.$$

Class C tube,

$$Z_2 = \frac{E}{I} = \frac{1,000}{0.15} = 6,667 \text{ ohms.}$$

Hence,

$$\text{Turns ratio} = \sqrt{\frac{Z_1}{Z_2}} = \sqrt{\frac{30,000}{6,670}} = 2.12:1.$$

The turns ratio, therefore, is 2.12:1.

**Ques. 4.165.** Indicate, by a simple diagram, a shunt-fed plate in a radio-frequency amplifier.

*Ans.* Figure 4-20 illustrates a simple shunt-fed plate radio-frequency amplifier.

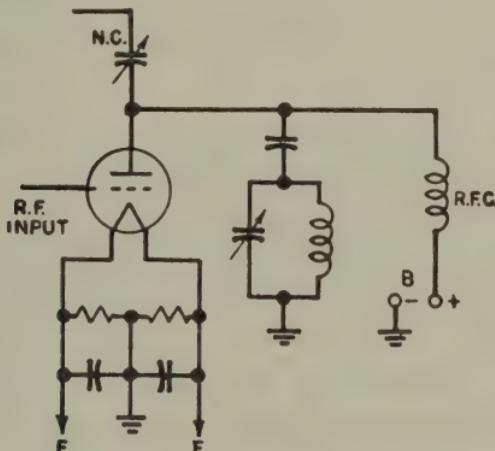


FIG. 4-20.—Simple shunt-fed plate arrangement.

**Ques. 4.166.** Indicate, by a simple diagram, a series-fed plate in a radio-frequency amplifier.

*Ans.* Figure 4-21 illustrates a simple series-fed plate radio frequency amplifier.

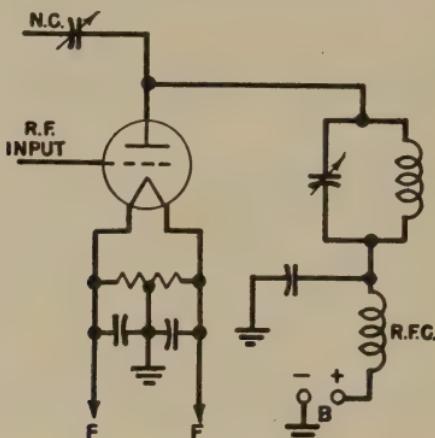


FIG. 4-21.—Simple series-fed plate arrangement.

**Ques. 4.167.** With respect to the unmodulated values, doubling the excitation voltage of a class B radio-frequency amplifier will result in what increase in radio-frequency power output?

*Ans.* The radio-frequency power output will be increased four times if the excitation voltage is doubled, assuming steady carrier values.

**Ques. 4.168.** Under what conditions does maximum plate dissipation of a class B linear amplifier occur?

*Ans.* The plate dissipation will be a maximum during the period in which the carrier frequency is unmodulated. The plates operate considerably cooler after modulation is applied.

**Ques. 4.169.** What may be the cause of a decrease in antenna current during modulation in a class B amplifier?

*Ans.* Downward deflection during modulation may be due to the following causes: poor tube, low-filament voltage, excessive value of load-impedance adjustment, open-filter

condenser in power supply, improper excitation or over-modulation.

**Ques. 4.170.** In adjusting the plate-tank circuit of a radio-frequency amplifier, should minimum or maximum plate current indicate resonance?

*Ans.* The direct-current plate milliammeter should show a minimum reading at the critical resonant point.

**Ques. 4.171.** What is the formula for determining the db loss or gain in a circuit?

*Ans.*

$$\text{Voltage gain or loss} = 20 \log_{10} \frac{E_1}{E_2} \text{ decibels.}$$

$$\text{Power gain or loss} = 10 \log_{10} \frac{P_1}{P_2} \text{ decibels.}$$

**Ques. 4.172.** What will occur if one tube is removed from a push-pull class A audio-frequency stage?

*Ans.* The second harmonic content which is normally balanced out in a push-pull amplifier, will reappear. Distortion will occur and the output power will be reduced. The hum component of the plate circuit will also be increased.

**Ques. 4.173.** What is the stage amplification obtained with a single triode operating with the following constants: plate voltage 250, plate current 20 milliamperes, plate impedance 5,000 ohms, load impedance 10,000 ohms, grid bias 5.4 volts, amplification factor 24.

*Ans.* The stage amplification will be 16.

*Solution:*

$$\text{Voltage gain} = \frac{\mu Z_o}{R_p + Z_o} = \frac{240,000}{15,000} = 16.$$

**Ques. 4.174.** Under what circumstances is neutralization of a triode radio-frequency amplifier not required?

## *RADIO OPERATING QUESTIONS AND ANSWERS*

*Ans.* Neutralization is not generally required in triode radio-frequency amplifiers when they are used as frequency doublers.

**Ques. 4.175.** Why is it necessary or advisable to remove the plate voltage from the tube being neutralized?

*Ans.* It is generally advisable to remove the plate voltage when neutralizing a radio-frequency amplifier since the presence of the high plate-current flow may cause self-oscillation the moment power is applied. This may damage the tube even before neutralizing adjustments are begun. More critical adjustments of balance, and lesser danger from shock, make the disconnection of high-voltage supply advisable.

**Ques. 4.176.** What is the rule regarding the posting of the station license of a regular broadcast station?

*Ans.* The station license and any other instrument of authorization or individual order concerning construction of the equipment or the manner of operation of the station shall be posted in a conspicuous place in the room in which the transmitter is located in such manner that all terms thereof are visible and the license of the station operator shall be posted in the same manner.

**Ques. 4.177.** Under what conditions may a broadcast station be operated at a reduced power other than specified in the station license?

*Ans.* The licensee of a broadcast station shall maintain the operating power of the station within the prescribed limits of the licensed power at all times, except that in an emergency, when, due to causes beyond the control of the licensee, it becomes impossible to operate with the full licensed power, the station may be operated at reduced power for a period of not to exceed 10 days, provided that the Commission and the inspector in charge shall be notified in writing immediately after the emergency develops.

**Ques. 4.178.** Unless otherwise specified in the license, what type of emission is authorized in all classes of broadcast licenses?

*Ans.* Type A3.

**Ques. 4.179.** When the transmitter of a regular broadcast transmitter is operated at 85 per cent modulation, what is the maximum permissible combined audio-harmonic output?

*Ans.* When the transmitter is operated with 85 per cent modulation, not over 10 per cent combined audio-frequency harmonics shall be generated by the transmitter.

**Ques. 4.180.** What types of broadcast stations are permitted to make charges for the transmission of programs?

*Ans.* Standard broadcast, international broadcast service stations and television stations.

**Ques. 4.181.** How frequently must the auxiliary transmitter of a regular broadcast station be tested?

*Ans.* The auxiliary transmitter shall be tested at least once each week to determine that it is in proper operating condition and that it is adjusted to the proper frequency, except that in case of operation in accordance with paragraph (c) of this section during any week, the test in that week may be omitted provided the operation under paragraph (c) is satisfactory. A record shall be kept of the time and result of each test operating under paragraph (c). Tests shall be conducted between midnight and 9 A.M., local standard time. Paragraph (c) reads as follows:

(c) The auxiliary transmitter shall be maintained so that it may be put into immediate operation at any time for the following purposes:

(1) The transmission of the regular programs upon the failure of the main transmitter.

(2) The transmission of regular programs during maintenance or modification work on the main transmitter, necessitating discontinuance of its operation for a period not to exceed five days.

(3) Upon request by a duly authorized representative of the Commission.

**Ques. 4.182. For what purpose is an auxiliary transmitter maintained?**

*Ans.* An auxiliary transmitter is maintained for the following reasons:

1. For the transmission of the regular programs upon the failure of the main transmitter.

2. For the transmission of regular programs during maintenance or modification work on the main transmitter, necessitating discontinuance of its operation for a period not to exceed five days.

**Ques. 4.183. If the plate ammeter in the last stage of a broadcast transmitter burned out, what should be done?**

*Ans.* No instrument indicating the plate current or plate voltage of the last radio stage, the antenna current, or the transmission-line current shall be changed or replaced without written authority of the Commission, except by instruments of the same make, type, maximum scale reading, and accuracy. Requests for authority to change an instrument may be made by letter or telegram giving the manufacturer's name, type number, serial number, and full-scale reading of the proposed instrument and the values of current or voltage the instrument will be employed to indicate. Requests for temporary authority to operate without an instrument or with a substitute instrument may be made by letter or telegram stating the necessity therefor and the period involved.

**Ques. 4.184. What is the frequency tolerance of non-commercial educational-broadcast stations?**

*Ans.* The transmitter of each noncommercial educational-broadcast station shall be equipped with automatic-frequency

control apparatus so designed and constructed that it is capable of maintaining the operating frequency within  $\pm 0.01$  per cent of the assigned frequency.

**Ques. 4.185.** Under what circumstances does a radiotelephone first-class license grant authority to the operator to operate a ship station licensed to use type A3 or A4 emission for communication with coastal telephone stations?

*Ans.* The holder of a radiotelephone first-class license is granted authority to operate a ship station licensed to use type A3 or A4 emission for communication with coastal telephone stations provided the ship station is not licensed to use power in excess of 100 watts, type A3 emission.

**Ques. 4.186.** The currents in the elements of a directive broadcast antenna must be held to what percentage of their licensed value?

*Ans.* Five per cent.

**Ques. 4.187.** Under what circumstances may a relay broadcast station be used?

*Ans.* The term "relay broadcast station" means a station licensed to transmit from points where wire facilities are not available, programs for broadcast by one or more broadcast stations, or orders concerning such programs.

**Ques. 4.188.** What are the permissible positive and negative tolerances of power of a standard broadcast station?

*Ans.* From +5 to -10 per cent.

**Ques. 4.189.** What is meant by "equipment tests" and "service tests" where these are mentioned in the Rules and Regulations of the Commission?

*Ans.* Upon completion of construction of a radio station in exact accordance with the terms of the construction permit, the technical provisions of the application therefor and the

rules and regulations governing the class of station concerned and prior to filing of application for license, the permittee is authorized to test the equipment for a period not to exceed 10 days. This test is referred to as the "equipment test."

When construction and equipment tests are completed in exact accordance with the terms of the construction permit, the technical provisions of the application therefor, and the rules and regulations governing the class of station concerned, and after an application for station license has been filed with the Commission showing the transmitter to be in satisfactory operating condition, the permittee is authorized to conduct service or program tests in exact accordance with the terms of the construction permit for a period not to exceed 30 days. This trial of the equipment is referred to as a "service test.",,

**Ques. 4.190. Name four required entries in the operating log of a regular broadcast station.**

*Ans.* The licensee of each broadcast station shall maintain program and operating logs and shall require entries to be made as follows:

In the operating log,

1. An entry of the time the station begins to supply power to the antenna, and the time it stops.
2. An entry of the time the program begins and ends.
3. An entry of each interruption to the carrier wave, its cause and duration.
4. An entry of the following each 30 minutes:
  - a. Operating constants of last radio stage (total plate current and plate voltage).
  - b. Antenna current.
  - c. Frequency monitor reading.
  - d. Temperature of crystal-control chamber if thermometer is used.
5. Log of experimental operation during experimental period. (If regular operation is maintained during this period, the above logs shall be kept).

a. A log must be kept of all operation during the experimental period. If the entries required above are not applicable thereto, then the entries shall be made so as to fully describe the operation.

**Ques. 4.191.** At broadcast stations using the direct method of computing output power, at what point in the antenna system must the antenna current be measured?

*Ans.* At the point of maximum current, which is as close to the ground as possible.

**Ques. 4.192.** For what purpose may a regular broadcast station, licensed to operate daytime or specified hours, operate during the experimental period without specific authorization?

*Ans.* The term "experimental period" means that period of time between 12 midnight and 6 A.M. This period may be used for experimental purposes in testing and maintaining apparatus by the licensee of any standard broadcast station, on its assigned frequency and with its authorized power, provided no interference is caused to other stations maintaining a regular operating schedule within such period. No station licensed for "daytime" or "specified hours" of operation may broadcast any regular or scheduled program during this period.

**Ques. 4.193.** What is the allowable frequency deviation, in percentage, for a broadcast station operating on 1,000 kilocycles?

*Ans.* The operating frequency of each broadcast station shall be maintained within 50 cycles of the assigned frequency until January 1, 1940, and thereafter the frequency of each new station or each station where a new transmitter is installed shall be maintained within 20 cycles of the assigned frequency, and after January 1, 1942, the frequency of all stations shall be maintained within 20 cycles of the assigned frequency. Hence, the deviation for an old transmitter on 1,000 kilocycles could be

as high as 0.005 per cent. The deviation for a new transmitter installed after January 1, 1940, must not exceed 0.002 per cent on 1,000 kilocycles. After January 1, 1942, all broadcast transmitters will be required to limit any deviation to within 20 cycles of the assigned frequency.

**Ques. 4.194.** What is the last audio-frequency amplifier stage which modulates the radio-frequency stage termed?

*Ans.* The last amplifier stage of the modulating wave which modulates a radio-frequency stage is called the modulator stage.

**Ques. 4.195.** How frequently must a remote-reading ammeter be checked against a regular-antenna ammeter?

*Ans.* Calibration shall be checked against the regular meter at least once a week.

**Ques. 4.196.** What factors enter into the determination of power of a broadcast station which employs the indirect method of measurement?

*Ans.* The operating power determined by indirect measurement from the plate-input power of the last radio stage is the product of the plate voltage ( $E_p$ ), the total plate current of the last radio stage ( $I_p$ ), and the proper factor ( $F$ ) as given by the following formula:

$$\text{Operating power} = E_p \times I_p \times F.$$

The factor  $F$  varies from 0.25 to 0.80, depending on the type of modulation used.

**Ques. 4.197.** What is the power that is actually transmitted by a regular broadcast station termed?

*Ans.* "Operating power" means the power that is actually supplied to the radio station antenna.

**Ques. 4.198.** Are the antenna current, plate current, etc., as used in the Rules and Regulations of the Commission modulated or unmodulated values?

*Ans.* "Plate-input power" means the product of the direct-plate voltage applied to the tubes in the last radio stage and the total direct current flowing to the plates of these tubes, measured without modulation.

"Antenna current" means the radio-frequency current in the antenna with no modulation.

**Ques. 4.199.** With reference to broadcast stations, what is meant by the "experimental period?"

*Ans.* The term "experimental period" means that period of time between 12 midnight and 6 A.M. This period may be used for experimental purposes in testing and maintaining apparatus by the licensee of any standard broadcasting station, on its assigned frequency with its authorized power, provided no interference is caused to any other stations maintaining a regular operating schedule within such period. No station licensed for "daytime" or "specified hours" of operation may broadcast any regular or scheduled program during this period.

**Ques. 4.200.** What is the rule governing the posting of the operator license?

*Ans.* The original license of each station operator shall be posted at the place where he is on duty or kept in his possession in the manner specified in the regulations governing the class of station concerned.

**Ques. 4.201.** What percentage of modulation capability is required of a broadcast station?

*Ans.* A licensee of a broadcast station will not be authorized to operate a transmitter unless it is capable of delivering satisfactorily the authorized power with a modulation of at least

## RADIO OPERATING QUESTIONS AND ANSWERS

85 per cent. When the transmitter is operated with 85 per cent modulation, not over 10 per cent combined audio-frequency harmonics shall be generated by the transmitter.

**Ques. 4.202.** Under what circumstances may radiotelegraph code be transmitted over a broadcast station?

*Ans.* Any station, including broadcast, which becomes aware that a mobile station is in distress may retransmit the distress message using the best possible type of emission to secure attention if such retransmission will serve to provide aid which cannot be secured in any other way.

**Ques. 4.203.** Define the "maximum-rated carrier power" of a broadcast station transmitter.

*Ans.* "Maximum-rated carrier power" is the maximum power at which the transmitter can be operated satisfactorily and is determined by the design of the transmitter and the type and number of vacuum tubes used in the last radio stage.

**Ques. 4.204.** Define the "plate-input power" of a broadcast station transmitter.

*Ans.* "Plate-input power" means the product of the direct-current plate voltage applied to the tubes in the last radio stage and the total direct current flowing to the plates of these tubes, measured without modulation. "Antenna current" means the radio-frequency current in the antenna with no modulation.

**Ques. 4.205.** Define "high-level" and "low-level" modulation.

*Ans.* "High-level" modulation is modulation produced in the last radio stage of the system.

"Low-level" modulation is modulation produced in an earlier radio stage than the final.

**Ques. 4.206.** What is the tolerance that is applied to the antenna currents in the various elements of a directional array?

*Ans.* Five per cent.

**Ques. 4.207.** What is the frequency tolerance which must be maintained at the present time by a standard broadcast station?

*Ans.* The operating frequency of each broadcast station shall be maintained within 50 cycles of the assigned frequency until January 1, 1940, and thereafter the frequency of each *new* station or each station where a *new* transmitter is installed shall be maintained within 20 cycles of the assigned frequency, and after January 1, 1942, the frequency of all stations shall be maintained within 20 cycles of the assigned frequency.

**Ques. 4.208.** What services may be rendered by a portable transmitter operating in the frequency band 550 to 1,500 kilocycles?

*Ans.* The term "portable transmitter" means a transmitter so constructed that it may be moved about conveniently from place to place, and is, in fact, so moved about from time to time, but not ordinarily used while in motion. In the standard broadcast band, such a transmitter is used in making field intensity measurements for locating a transmitter site for a standard broadcast station. A portable broadcast station will not be licensed in the standard broadcast band for regular transmission of programs intended to be received by the public.

**Ques. 4.209.** Name three technical changes in a broadcast station transmitter which cannot be made without the authority of the Commission.

*Ans.* No licensee shall change, in the last radio stage, the number of vacuum tubes to vacuum tubes of different power rating or class of operation, nor shall it change system of modulation without the authority of the Commission. Also, no instrument indicating the plate current or plate voltage

of the last radio stage, the antenna current or the transmission-line current shall be changed or replaced without the written authority of the Commission, except by instruments of the same make, type, maximum scale reading, and accuracy.

**Ques. 4.210.** Describe the adjustments which would be necessary to be made to the final amplifier stage of a broadcast transmitter to reduce the power output to one-half that previously being delivered, if low-level modulation is used. If high-level modulation is used.

*Ans.* Proceed by reducing the radio-frequency drive from the preceding stages to the point at which the final power-amplifier plate current reads the reduced-current value for the reduced power. Then proceed to adjust the power-amplifier output coupling circuit until the required efficiency is obtained. Then carefully adjust the plate-tank condenser for maximum tank current and minimum plate current.

The antenna circuit must now be tuned carefully by adjusting the antenna-coil tuning taps. The plate circuit should again be checked for minimum reading on the direct-current plate milliammeter.

The speech-input level for operating at the reduced power must be lowered in order to prevent excessive audio-frequency excitation. The correct level is obtained by finding the ratio of the power before reduction and dividing it by the reduced power value. The required attenuation is then obtained by the insertion of a pad network which retains both the input and output impedance relations as well as the desired attenuation.

Once the readings at the reduced power have been recorded, it will be a relatively simple matter to again adjust the transmitter from the high-power to the low-power adjustment without much delay.

**Ques. 4.211.** What is the frequency tolerance allowed an international broadcast station?

*Ans.* 0.005 per cent.

**Ques. 4.212.** What is the required full-scale accuracy required in the ammeters and voltmeters associated with the final radio stage of a broadcast transmitter?

*Ans.* Accuracy shall be at least 2 per cent of the full-scale reading.

**Ques. 4.213.** Name and define the various classes of emissions which may be radiated by a radio transmitter.

*Ans.* 1. Continuous waves: Produced as follows:

Vacuum type transmitters—Types A0 to A5 (as defined below).

Arc transmitters—Types A1 and A2 only.

Type A0. Waves the successive oscillations of which are *identical* under fixed conditions.

Type A1. Telegraphy on pure continuous waves. A continuous wave which is keyed according to a telegraph code.

Type A2. Modulated telegraphy. A carrier wave modulated at one or more audible frequencies; the audible frequency or frequencies or their combination with the carrier wave being keyed according to a telegraph code.

Type A3. Telephony. Waves resulting from the modulation of a carrier wave by frequencies corresponding to the voice, to music, or to other sounds.

Type A4. Facsimile. Waves resulting from the modulation of a carrier wave by frequencies produced at the time of the scanning of a fixed image with a view to its reproduction in a permanent form.

Type A5. Television. Waves resulting from the modulation of a carrier wave by frequencies produced at the time of the scanning of fixed or moving objects.

2. Damped waves:

Type B. Produced by spark transmitters.

**Ques. 4.214.** If a broadcast transmitter employs seven tubes of a particular type, how many spare tubes of the same type are required to be kept on hand in accordance with FCC regulations?

*Ans.* Three, in accordance with the following schedule:

Number of Tubes of Each Type Employed	Spares Required
1 or 2	1
3 to 5	2
6 to 8	3
9 or more	4

**Ques. 4.215.** Describe the various methods by which a broadcast station may compute its operating power, and state the conditions under which each method may be employed.

*Ans.* After July 1, 1940, all broadcast stations shall employ the *direct-measurement method* of determining operating power. With this method, the antenna-input power (operating power) is determined by multiplying the antenna resistance by the square of the antenna current, both being measured at the base of the antenna, the point of maximum current.

In case of an emergency where the licensed antenna has been damaged or destroyed by storm or other cause beyond the control of the licensee, or pending completion of authorized changes in the antenna system, the *indirect measurement method* of determining operating power may be employed. With this method, the plate-input power to the last radio stage is taken as the operating power. (See Ques. 4.196.)

**Ques. 4.216.** What portion of the scale of an antenna ammeter having a square-law scale is considered as having acceptable accuracy for use at a broadcast station?

*Ans.* No scale division above one-third full-scale reading (in amperes) shall be greater than one-thirtieth of the full-scale reading.

*Example:* An ammeter meeting standard requirements and having a full-scale reading of 6 amperes is acceptable for reading currents from 2 to 6 amperes provided no scale division between 2 and 6 amperes is greater than  $\frac{1}{30}$  of 6 amperes, 0.2 ampere.

**Ques. 4.217.** Define: "Amplifier gain," "percentage deviation," "stage amplification," and "percentage of modulation." Explain how each is determined.

*Ans.* Amplifier gain is the ratio of output to input signal amplitude (voltage gain) or the ratio of output to input signal power (power gain). This ratio may be expressed in decibels.

"Percentage deviation" is the percentage which a carrier frequency varies from its stable frequency value.

"Stage amplification" is the ratio of the output to input voltage or power of a single amplifier tube with its associated input- and output-coupling system. This ratio is also expressed in decibels gain.

"Percentage of modulation" is the term applied when the modulation factor is expressed as a percentage, and is the ratio of the maximum departure, positive or negative, of the envelope of a modulated wave from its unmodulated value. (I.R.E. Standards definition, 1938.)

**Ques. 4.218.** Define "auxiliary broadcast transmitter" and state the conditions under which it may be used.

*Ans.* "Auxiliary transmitter" means a transmitter maintained only for transmitting the regular programs of a station in case of failure of or work on the main transmitter.

**Ques. 4.219.** What is the purpose of using a frequency standard or service independent of the transmitter-frequency monitor or control?

*Ans.* To assure that the transmitter is on the assigned frequency and within tolerance limits. It also permits a check upon the station monitor.

**Ques. 4.220.** Discuss the characteristics of a modulated class C amplifier.

*Ans.* The class C amplifier has very high efficiency. It is generally operated in the vicinity of 60 per cent efficiency for

modulated stages. It operates with a grid-bias adjustment of approximately twice the cut-off value and a tank circuit impedance of three or four times the tube impedance. These adjustments permit a fairly linear adjustment between the tank current and plate voltage. The continuous power output with 100 per cent modulation is 1.5 times the power at zero modulation. It undergoes a power variation of from 0 to 4 times the carrier power under 100 per cent modulation.

**Ques. 4.221.** What is the purpose of neutralizing a radio-frequency amplifier stage?

*Ans.* To prevent the amplifier from going into self-oscillation and to avoid serious overloading.

**Ques. 4.222.** When the authorized nighttime power of a standard broadcast station is different from the daytime power and the operating power is determined by the "indirect" method, which of the efficiency factors established by FCC rules is used?

*Ans.* Use the efficiency factor given for the maximum licensed power of the station.

**Ques. 4.223.** Describe the technique used in frequency measurements employing a 100-kilocycle oscillator, a 10-kilocycle multivibrator, a heterodyne-frequency meter of known accuracy, a suitable receiver, and standard-frequency transmission.

*Ans.* The principle involved in all primary-frequency standards is based upon the zero beat method. In the primary method, employing a 100-kilocycle oscillator of stabilized frequency, is a series of multivibrators that operates a clock in synchronism with the oscillator frequency. Now, if a secondary-frequency measuring system employing a heterodyne-frequency meter is adjusted to zero beat with a receiver tuned to a standard-frequency transmission station, these frequencies may be intercoupled for any degree of calibration desired. In this manner primary- and secondary-frequency standards may readily be obtained.

**Ques. 4.224.** What is the power specified in the instrument of authorization for a standard broadcast station called?

*Ans.* "Authorized power" or "licensed power."

**Ques. 4.225.** What is the effect of 10,000-cycle modulation of a standard broadcast station on adjacent channel reception?

*Ans.* This will cause strong interference since it produces a side band at the frequency of the carrier of the adjacent channel.

**Ques. 4.226.** What system of connections for a three-phase, three-transformer bank will provide maximum secondary voltage?

*Ans.* The delta-Y connection, where the primary is connected in delta and the secondary in "Y" as illustrated in Fig. 2-38 and Fig. 4-2.

**Ques. 4.227.** Draw a diagram and describe the electrical characteristics of an electron-coupled oscillator circuit.

*Ans.* Figure 2-9 illustrates a simple electron-coupled oscillator. The cathode, grid, and screen grid operate as a Hartley triode oscillator. The circuit is very little affected by variations in plate-circuit impedance since the current in a tetrode or pentode is nearly independent of plate voltage. Power, however, is delivered from the oscillator circuit to the plate circuit by the flow of electrons to the plate. The frequency stability of the oscillator is very good.

**Ques. 4.228.** In frequency measurements using the heterodyne "zero beat" method, what is the best ratio of signal e.m.f. to calibrated heterodyne oscillator e.m.f.?

*Ans.* An approximate 1:1 ratio is desirable in order that the resultant beat note shall be strong compared with the weaker beat notes also present.

## ELEMENT 5

### RADIOTELEGRAPH

**Ques. 5.01.** What is the meaning of ampere turns?

*Ans.* The magnetomotive force produced by the flow of an electric current in a coil is proportional to the total quantity of charge circling the coil in one second. Thus, it is proportional to the product of the current in each turn and the total number of turns in the coil. The magnetomotive force can be conveniently expressed in ampere turns which are computed by the formula,

$$\text{ampere turns} = N \times I$$

where  $N$  is the number of turns and  $I$  the current flowing.

**Ques. 5.02.** What is the meaning of "electrolyte"? List four types of radio equipment in which it may be used.

*Ans.* "Electrolyte" may be defined as an acid or alkaline solution. Electrolyte is used in the following types of radio equipment:

1. Storage battery.
2. Electrolytic condenser.
3. Electrolytic rectifier.
4. Electrolytic interrupter.
5. Electrolytic detector.

**Ques. 5.03.** Name at least five pieces of radio equipment which make use of electromagnets.

*Ans.* Electromagnets are used in the following pieces of radio equipment:

1. Overload and underload circuit breakers.

2. Headphones.
3. Relays.
4. Meters.
5. Motors.
6. Generators.
7. Loud-speakers.

**Ques. 5.04.** How many watts equal 1 horsepower?

*Ans.* 746 watts.

**Ques. 5.05.** What is the meaning of "residual magnetism"?

*Ans.* The magnetism which still remains in temporary magnets after the magnetizing current has been removed.

**Ques. 5.06.** If two 10-watt 500-ohm resistors are connected in series, what is the total power-dissipation capability?

*Ans.* Each resistance has a capability of 10 watts dissipation, thus the total power-dissipation capability will be 20 watts.

**Ques. 5.07.** A milliammeter with a full-scale deflection of one milliampere and having an internal resistance of 25 ohms is used to measure an unknown current, by shunting it with a 4-ohm resistance. When the meter reads 0.4 milliamperes, what is the actual value of current?

*Ans.*  $I = 2.9$  milliamperes, or 0.0029 ampere. (See Ques. 2.58 for details.)

*Solution:*

$$I = I_M \left( 1 + \frac{R_M}{R_S} \right) = 0.4 \left( 1 + \frac{25}{4} \right) = 2.9 \text{ milliamperes}$$

where  $I_M$  = meter reading,  $R_M$  = resistance of the meter,  $R_S$  = resistance of the shunt.

**Ques. 5.08.** If two 10-watt 500-ohm resistors are connected in parallel, what is the total power-dissipation capability?

*Ans.* The total power-dissipation capability will be 20 watts.

**Ques. 5.09.** What is the maximum current-carrying capacity of a resistor marked "5,000 ohms, 200 watts"?

*Ans.*

$$I = \sqrt{\frac{P}{R}} = 0.2 \text{ ampere.}$$

**Ques. 5.10.** What factors determine the heat generated in a conductor carrying an electric current?

*Ans.* The current-flow-squared value and the resistance.  $P = I^2R$  watts.

**Ques. 5.11.** Two resistances of 18 and 15 ohms are connected in parallel; in series with this combination is connected a 36-ohm resistance; in parallel with this total combination is connected a 22-ohm resistance. The total current flowing through the combination is 5 amperes. What is the current value in the 15-ohm resistance?

*Ans.* The current flow through the 15-ohm resistance will be  $0.9+$  amperes. To solve this problem by simple arithmetic and Ohm's law proceed as follows:

1. Reduce the parallel combination of the 15- and 18-ohm resistances to the effective resistance,

$$R_{eff} = \frac{R \times R}{R + R} = 8.18+ \text{ ohms.}$$

2. Add the effective resistance to the 36-ohm series resistance, 44.18 ohms.

3. Obtain the total effective resistance of the 44.18-ohm and the 22-ohm parallel combination,

$$R_{eff} = \frac{R \times R}{R + R} = 14.68+ \text{ ohms.}$$

4. Determine the applied voltage across the entire combination,  $E_a = IR = 5 \times 14.68 = 73.4$  volts.

5. Find the current flow through the 22-ohm resistance,  $I = \frac{E}{R} = 3.341$  amperes.

6. Find the current through the remaining branch,

$$5 - 3.341 = 1.659 \text{ amperes.}$$

7. Find the voltage developed across the 15- and 18-ohm effective combination of  $8.18+$  ohms,

$$E = IR = 1.659 \times 8.18+ = 13+ \text{ volts.}$$

8. Thus the current through the 15-ohm resistance is found  $I = \frac{E}{R} = \frac{13+}{15} = 0.9+$  ampere.

**Ques. 5.12.** What method is used to obtain more than one voltage value from a fixed-voltage direct-current source?

*Ans.* By the use of a voltage-divider resistance or potentiometer.

**Ques. 5.13.** Two resistors are connected in series. The current through these resistors is 3 amperes. Resistance 1 has a value of 50 ohms; resistance 2 has a voltage drop of 50 volts across its terminals. What is the total impressed e.m.f.?

*Ans.* The total impressed e.m.f. is 200 volts. The current through the 50-ohm resistor is  $I = \frac{E}{R}$  or,  $E = IR = 3 \times 50 = 150$  volts. Since a 50-volt drop is known to be present across resistance 2, the total or impressed e.m.f. must be the sum of the two  $IR$  drops or 200 volts.

**Ques. 5.14.** A circuit is passing a current of 3 amperes. The internal resistance of the source is 2 ohms. The total external resistance is 50 ohms. What is the terminal voltage of the source?

*Ans.* The terminal voltage of a source is always less than the open circuited voltage by an amount  $I \times R$  (internal resistance). Thus the terminal voltage in this circuit is 150 volts. Proof:  $E = IR = 3 \times 50 = 150$  volts.

**Ques. 5.15.** A 10,000-ohm 100-watt resistor, a 40,000-ohm 50-watt resistor, and a 5,000-ohm 10-watt resistor are connected in parallel. What is the maximum value of total current through this combination which will not exceed the wattage rating of any of the resistors?

*Ans.* The maximum value of current flow through this combination is 0.07 ampere. The power dissipated in each

resistance,  $\frac{E^2}{R}$ , must not exceed the rating of the resistance.

Since all of the resistances are in parallel, it is obvious that the calculations are based upon the 5,000-ohm 10-watt resistor. Hence, we must determine what value of current flow through this resistor will not exceed 10 watts of power dissipation. Thus, we find the current value through this resistance by the

$$\text{equation, } I = \sqrt{\frac{P}{R}} = \sqrt{\frac{10}{5,000}} = 0.0447 \text{ ampere.}$$

*Proof:*

$$P = I^2 \times R = 0.0447^2 \times 5,000 = 10 \text{ watts.}$$

The applied voltage may now readily be determined,

$$E_a = I \times R = 0.0447 \times 5,000 = 223.5 \text{ volts}$$

and 
$$P = \frac{E^2}{R} = \frac{50,000}{5,000} = 10 \text{ watts.}$$

The current flow through each of the remaining resistors is then obtained by Ohm's law,

$$I_2 = \frac{223.5}{40,000} \text{ amperes} \quad \text{and} \quad I_1 = \frac{223.5}{10,000} \text{ amperes.}$$

The sum of all the branch currents is, therefore, the total current, or 0.07 ampere.

**Ques. 5.16.** What is the ratio of peak to effective voltage values of a sine wave?

*Ans.* The ratio is  $\frac{1}{0.707} = 1.414:1$ .

**Ques. 5.17.** If a direct-current voltmeter is used to measure effective alternating voltages by the use of a bridge-type full-wave rectifier of negligible resistance, by what factor must the meter readings be multiplied to give corrected readings?

*Ans.* The meter reading must be multiplied by 1.11 to obtain corrected readings.

**Ques. 5.18.** By what factor must the voltage of an alternating-current circuit, as indicated on the scale of an alternating-current voltmeter, be multiplied in order to obtain the average voltage value?

*Ans.* Since the meter reading is an effective value indication it will be necessary to multiply the scale reading by 0.9 in order to obtain average values.

$$E_{av} = E_{eff} \times 0.9.$$

**Ques. 5.19.** By what factor must the voltage of an alternating-current circuit, as indicated on the scale of an alternating-current voltmeter, be multiplied in order to obtain the peak value?

*Ans.* The meter reading must be multiplied by 1.414 to obtain peak values.

**Ques. 5.20.** What is the ratio of peak to average value of a voltage sine wave?

*Ans.* The ratio is  $\frac{1}{0.637} = 1.57:1$ .

**Ques. 5.21.** What is the meaning of the term "phase difference"?

*Ans.* Phase difference is a measure of the time displacement of one sine wave from another at the same frequency. It is usually expressed in electrical degrees, of which there are 360 in each sinusoidal cycle.

**Ques. 5.22.** What is the meaning of the term "leading power factor"?

*Ans.* The power in an alternating-current circuit is equal to the product of voltage and current and the cosine of the angle between them. Power factor is the cosine of the phase angle expressed in per cent. The cosine of the angle is equal to the ratio of the resistance of the impedance  $R/Z$ . A "leading power factor" is an expression of that condition in an alternating-current circuit where capacitative reactance predominates since the current in that type of circuit is leading the voltage between zero and 90 degrees. (See also Ques. 2.38 and 3.10 for practical formulas.)

**Ques. 5.23.** The product of the readings of an alternating-current voltmeter and ammeter in an alternating-current circuit is called what?

*Ans.* This product is referred to as the "apparent power" or "volt-amperes."

**Ques. 5.24.** In what units is the alternator output ordinarily rated?

*Ans.* Preferably in volt-amperes, but radio manufacturers invariably rate output in watts.

**Ques. 5.25. Define "power factor."**

*Ans.* (See Ques. 2.38, 3.10, and 5.22.)

**Ques. 5.26. What is the total inductance of two inductance coils, connected in series, but without any mutual coupling?**

*Ans.*  $L_{eff} = L_1 + L_2 \pm 2M$ . In this case, therefore, the total inductance is the sum of the two inductances expressed in henrys.

**Ques. 5.27. What is the total inductance of two inductances connected in parallel but without any mutual coupling?**

*Ans.* When the coils are so far apart that mutual inductances are negligible, inductances in parallel are combined like resistances in parallel. (See Ques. 2.55 and Ques. 6.08 for formulas.)

**Ques. 5.28. A series inductance, acting alone in an alternating-current circuit has what properties?**

*Ans.* It has the properties of generating a counter e.m.f., developing kinetic energy, and causing the current to lag behind the voltage by 90 degrees. It acts as an alternating-current resistance and is known as inductive reactance,  $X_L$ . The reactance value varies directly with frequency. The series inductance also has a smoothing effect on circuit variations and tends to improve the regulation.

**Ques. 5.29. What is the total reactance of a series alternating-current circuit containing no resistance, and an equal value of inductive and capacitative reactance?**

*Ans.* The total reactance is zero.

**Ques. 5.30. What is meant by the "flywheel" effect of a tank circuit?**

*Ans.* The circuit inertia set up by the kinetic energy of the inductance tending to keep the circuit oscillating. The condenser discharges through the inductance and the energy developed by the inductance in the collapsing field recharges the condenser in the opposite direction.

**Ques. 5.31.** What may be the effects of shielding applied to radio-frequency inductances?

*Ans.* The inductance of the coil decreases. The capacity of the coil increases. The *Q* of the coil decreases.

**Ques. 5.32.** What is the effect on the resonant frequency of connecting a capacitance in series with an antenna?

*Ans.* The effective capacity of the entire antenna system is reduced. The resonant frequency increases as the capacitive reactance increases, *i.e.*; as the size of the series capacitance is reduced.

**Ques. 5.33.** What is the total impedance of a capacitance and inductance having equal values of reactance, when connected in parallel?

*Ans.* The total reactance will be zero, and the impedance infinite, looking in.

**Ques. 5.34.** What factors determine the efficiency of a power transformer?

*Ans.* The core structure, the character of the core material, the size of the wire used, and flux leakage. The amount of loading.

**Ques. 5.35.** What factors determine the no-load voltage ratio of a power transformer?

*Ans.* The turns ratio *N*:

$$N = \frac{E_P}{E_S} = \frac{N_P}{N_S}$$

$$E_S = \frac{N_S}{N_P} \times E_P$$

**Ques. 5.36.** What factors determine the current ratios of primary and secondary in a power transformer?

*Ans.* The currents in the primary and the secondary of a power transformer are approximately in the inverse ratio of the corresponding turns.

$$\frac{I_P}{I_S} = \frac{N_S}{N_P}$$

The size of wire also affects the current ratio.

**Ques. 5.37.** A radio receiver has a power transformer and rectifier designed to supply plate voltage to the vacuum tubes at 250 volts when operating from a 110-volt 60-cycle supply. What will be the effect if this transformer primary is connected to a 110-volt direct-current source?

*Ans.* The primary winding will seriously overheat and burn unless adequately protected by fuses.

**Ques. 5.38.** What is the relationship between the turns ratio and the impedance ratio of the windings of a transformer?

*Ans.*

$$\text{Turns ratio} = \sqrt{\frac{Z_P}{Z_S}}$$

$Z_P$  = primary impedance.

$Z_S$  = secondary impedance.

**Ques. 5.39.** Why should the cathode of an indirectly heated type of vacuum tube be maintained at nearly the same potential as the heater circuit?

*Ans.* To prevent cathode leakage which might be caused by voltage breakdown between the cathode and the filament. Also to reduce stray fields existing between the cathode and the filament.

**Ques. 5.40.** Why is it impractical to reactivate oxide-coated filaments?

**Ans.** Because the oxide coating is nearly all on the surface of the filament. The reactivation process here applied would merely decrease the degree of oxide.

**Ques. 5.41.** What types of vacuum-tube emitting surfaces respond to the reactivation?

**Ans.** Thoriated-tungsten filaments.

**Ques. 5.42.** Describe how reactivation may be accomplished?

**Ans.** The filament is subjected to a momentary voltage surge of a higher value than the normal operating voltage and then to a slightly lower voltage, but for a longer period of time. It is important that the plate potential be disconnected during this operation. (See also Ques. 2.157.)

**Ques. 5.43.** Is a tungsten filament operated at a higher or lower temperature than a thoriated filament? Why?

**Ans.** The tungsten filament is operated at a higher filament temperature because the electron emission characteristic is considerably lower.

**Ques. 5.44.** What is indicated when a blue glow is noticed within a vacuum-tube envelope?

**Ans.** If the glow occurs between the plate and filament elements this indicates the presence of gas.

**Ques. 5.45.** What is the function of the grid leak in a grid-leak type of detector?

**Ans.** In a grid-leak type of detector, the grid and cathode act as a diode rectifier. The grid leak serves as a load resistance across which the modulation (signal) voltage is developed and applied to the grid of the tube which then operates as an audio-frequency amplifier. Operating bias is developed automatically by rectification of the signal and is zero in the absence of the signal. Since for small signals the bias is small, the  $g_m$  of the tube is maximum and the gain of the stage is high.

**Ques. 5.46.** What effect does an incoming signal have upon the plate current of a grid-leak type detector vacuum tube?

*Ans.* The automatic bias action decreases the plate current.

**Ques. 5.47.** What effect does an incoming signal have upon the value of plate current of a power detector tube?

*Ans.* The plate current rises during the signal periods.

**Ques. 5.48.** Why is it sometimes necessary to provide a radio-frequency filter in the plate circuit of a detector tube?

*Ans.* To by-pass the plate radio-frequency variations around the high impedance of the audio-transformer primary or headphones. This filter may be used to peak the 500-cycle audio beat note by effecting a parallel resonant condition.

**Ques. 5.49.** Explain how power detection is accomplished?

*Ans.* Power detection, or more accurately, linear detection, is accomplished by operating the detector tube with a large value of grid bias almost to the point of plate-current cut-off. The plate voltage is of a considerably higher value than normal. The name "power detection" is used because it generally operates with large applied signal voltages.

**Ques. 5.50.** Explain how grid-leak detection is accomplished.

*Ans.* Grid-leak detection is accomplished by the insertion of a grid condenser and shunt resistance connected in series with the grid. Operating bias is developed across the grid resistance by the flow of rectified grid current.

**Ques. 5.51.** Explain how diode detection is accomplished?

*Ans.* Diode detection is accomplished by using either a triode type or special diode type of tube. In the case of the former, the grid is used as the diode element while the plate is

connected to cathode or ground. The grid is then connected to one end of the radio-frequency input transformer while the other end of the transformer is connected through a high resistance (500,000 ohms) to the cathode of the tube. A small radio-frequency by-pass condenser of approximately 0.0001 microfarad is connected in shunt with the resistance. The audio-frequency voltage developed across the resistance by rectification is then applied to the grid of an audio-frequency amplifier tube. With the diode type of tube the diode plate or plates are connected together and then connected as the grid was in the preceding explanation.

**Ques. 5.52.** What is the principal advantage of transformer coupling compared to resistance coupling, as used in audio-frequency amplifiers?

*Ans.* Higher amplification may be obtained owing to the primary-to-secondary step-up ratios. Voltage step-up ratios with transformers range between 1:1.5 to 1:10. Resistance ratios are 1:1.

**Ques. 5.53.** Why is it necessary to use two tubes in class B audio amplification?

*Ans.* Since this type of amplifier operates at cut-off, a single tube would amplify only one-half of the signal cycle and serious distortion would result. Two tubes complete the cycle.

**Ques. 5.54.** What are the advantages of push-pull amplification as compared to single-ended amplification?

*Ans.* Push-pull amplification reduces harmonic distortion caused by the second harmonic, reduces hum, eliminates core saturation, and develops a more symmetrical reproduction of the input wave form than the single-ended amplifier.

**Ques. 5.55.** Why is it not feasible to employ a vacuum-tube operated class C as an audio amplifier, either singly or in push-pull?

*Ans.* Because there is too much distortion present in the output of the class C amplifier to make it feasible for use on audio frequencies. Hence, class C amplifiers are used primarily in the amplification of the unmodulated radio-frequency carrier wave in radio transmitters. Note that in radio-frequency circuits a tank circuit is available to minimize distortion.

**Ques. 5.56.** Why is an audio transformer seldom employed as the output device to be used in the plate circuit of a tetrode audio-amplifier stage?

*Ans.* The plate impedance of a tetrode ranges between 300,000 and 1,000,000 ohms. To satisfy load conditions, the transformer would require a primary inductance value of 300 to 500 or more henrys. This would necessitate a transformer with large physical dimension as well as one difficult to construct with a flat-frequency response. Another reason is that the tetrode possesses a large voltage amplification factor and, therefore, does not require large output step-up ratios.

**Ques. 5.57.** If a final radio-frequency amplifier, operated as class B linear, were excited to saturation with no modulation, what would be the effects when undergoing modulation?

*Ans.* The amplifier plate current would be unable to increase as it should on modulation peaks but would decrease on the troughs. This would result in serious audio-frequency distortion and a downward deflection of the plate current meter.

**Ques. 5.58.** Under what class of amplification are the vacuum tubes in a linear radio-frequency stage, following the modulated stage, operated?

*Ans.* Class B.

**Ques. 5.59.** What class of amplifier should be employed in the final amplifier stage of a radiotelegraph transmitter for maximum plate efficiency?

*Ans.* Class C.

**Ques. 5.60.** Discuss the effects of insufficient radio-frequency excitation on a class C modulated radio-frequency amplifier insofar as the output signal wave form is concerned.

*Ans.* The negative peaks of the modulation envelope will be flattened. A positive carrier shift will result.

**Ques. 5.61.** What factors are most important in the operation of the vacuum tube as a frequency doubler?

*Ans.* The most important factors are:

1. Very large value of grid-bias adjustment.
2. High plate voltages.
3. High radio-frequency voltage excitation.
4. Low C-tank circuit value.
5. Proper adjustment of the doubler plate circuit to the harmonic of the frequency applied to its grid.

**Ques. 5.62.** What is the primary purpose of the suppressor grid of a pentode?

*Ans.* To reduce *secondary emission* and improve the linearity of the plate characteristics.

**Ques. 5.63.** What is the primary purpose of the screen grid of a tetrode?

*Ans.* The primary purpose is to act as an electrostatic shield. It serves to reduce the interelectrode grid-plate capacity and raise the electron acceleration to the plate. Greater plate resistance and increased circuit stability are resultant contributing factors.

**Ques. 5.64.** What is the primary purpose of the control grid of a triode?

*Ans.* The control grid provides a means by which the signal voltage can vary the plate current while drawing little or no current from the signal source.

**Ques. 5.65.** A triode transmitting tube, operating with a plate voltage of 1,250 volts, has a filament voltage of 10, filament current of 3.25 amperes, and a plate current of 150 milliamperes. The amplification factor is 25. What value of control grid bias must be used for operation as a class C amplifier?

*Ans.* A grid bias of approximately -125 volts. For class C amplification the ratio  $\frac{E_p}{\mu} \times 2.5$  may be used for determining grid bias with fairly accurate results.

**Ques. 5.66.** Name four materials which can be used as crystal detectors.

*Ans.* Carborundum, galena, iron-pyrites, silicon, and zincite-bornite.

**Ques. 5.67.** Why do headphones have high impedance windings?

*Ans.* As radio headphones are sometimes called upon to act as the load on the final audio-amplifier tube, it is desirable that their resistance approach the impedance-match condition for distortionless amplification, which is twice the tube's plate resistance. Generally speaking, therefore, radio headphones should have a direct-current resistance of 2,000 ohms or more. Their alternating-current impedance would, of course, exceed this value owing to the reactance effect in the magnet windings.

**Ques. 5.68.** What are the objections to the operation of a regenerative, oscillating-detector receiver, when directly coupled to the antenna?

## RADIO OPERATING QUESTIONS AND ANSWERS

*Ans.* An oscillating detector is in reality a miniature transmitter. Heterodyne interference in nearby receivers will be produced.

**Ques. 5.69.** What controls determine the selectivity of a three-circuit tuner?

*Ans.* The regenerative feedback control, the secondary tuning condenser, the antenna series condenser, and the antenna coupling coil.

**Ques. 5.70.** A superheterodyne receiver is adjusted to 2,738 kilocycles. The intermediate frequency is 475 kilocycles; what is the frequency to which the grid circuit of the second detector must be tuned?

*Ans.* 475 kilocycles.

**Ques. 5.71.** Explain the reasons why a superheterodyne receiver may not be successfully used for reception of frequencies very near the frequency of the intermediate amplifier.

*Ans.* Frequencies near the intermediate-frequency range would pass through without any mixing effect. In other words, the intermediate frequency would function as a simple untuned radio-frequency amplifier to these frequencies. At the same time the mixer oscillator may cause a continuous squeal in the output.

**Ques. 5.72.** A superheterodyne receiver, having an intermediate frequency of 465 kilocycles and tuned to a broadcast station on 1,450 kilocycles, is receiving severe interference from an "image" signal. What is the frequency of the interfering station?

*Ans.* 2,380 kilocycles.

**Ques. 5.73.** A superheterodyne receiver is tuned to 1,712 kilocycles and the intermediate frequency is 456 kilocycles. What is the frequency of the mixer oscillator?

*Ans.* 2,168 kilocycles.

**Ques. 5.74. Describe a "superregenerative" receiver.**

*Ans.* The superregenerative receiver is essentially the same as a three-circuit regenerative receiver with the exception that a local generating frequency of, say, 25,000 cycles is coupled to the plate circuit. The purpose of this local oscillator is to increase the regenerative effect beyond the point in which the receiver would normally go into self-oscillation. In other words, the local oscillator supplies a *quench* frequency which continuously interrupts the oscillation frequency and, therefore, the degree of regeneration can be built up to tremendous proportions.

**Ques. 5.75. Why are the unused portions of inductances in receivers usually shorted?**

*Ans.* To eliminate "dead end" losses.

**Ques. 5.76. What is the "mixer" tube in a superheterodyne?**

*Ans.* The "mixer" tube or first detector is that tube in which the combining of the signal frequency and the local oscillator frequency takes place. It is in the mixer tube that the intermediate-beat frequency is generated.

**Ques. 5.77. What is the purpose of a tuned radio-frequency amplifier stage ahead of the mixer stage in a superheterodyne receiver?**

*Ans.* It serves as a preselector stage to eliminate image interference. It improves the signal-to-noise ratio in the lower frequency bands.

**Ques. 5.78. What is the advantage of using iron cores of special construction in radio-frequency transformers and inductances?**

*Ans.* This type of transformer permits more effective band-width adjustments in receivers thereby providing better

## *RADIO OPERATING QUESTIONS AND ANSWERS*

high-fidelity response. They also make for better circuit stability in the reception of unstable frequencies particularly in the ultra-high-frequency bands. Some types are adjustable for variable selectivity.

**Ques. 5.79.** If signals are heard with the headphones plugged into the detector plate circuit of a receiver, but no signals are heard when the phones are plugged into the first audio-frequency stage plate circuit, what might be the cause and how could it be remedied?

*Ans.* The primary or secondary winding of the audio transformer may have opened. Substitute resistance coupling for the opened section.

**Ques. 5.80.** Name three causes of an audio "howl" in a regenerative receiver.

*Ans.* Howling might be caused by a microphonic detector tube, too much regeneration, acoustic feedback, open grid leak.

**Ques. 5.81.** Name four reasons which would prevent a regenerative receiver from oscillating.

*Ans.* Open plate by-pass condenser, open grid condenser, insufficient plate voltage, low filament emission, coil losses resulting from moisture absorption, reversed tickler winding or shorted grid condenser.

**Ques. 5.82.** What is the advantage of heterodyne reception as compared to autodyne reception?

*Ans.* The heterodyne method of beat reception has the advantage over autodyne beat reception in slightly greater sensitivity and wider range of beat production.

**Ques. 5.83.** How is automatic volume control accomplished in a receiver?

**Ans.** Automatic volume-control action is generally developed in the diode load section of the diode detector. The rectified signal voltage developed across this load produces a direct-current voltage component which makes one end of the resistance negative with respect to the cathode. By connecting to the negative end through a filter resistor and a bypass condenser this voltage is fed to the return lead of the variable- $\mu$  radio-frequency tube(s) to be controlled. The grid voltage of the radio-frequency amplifier is, therefore, reinforced by the direct-current potential developed across the diode load and the radio-frequency signal peaks are diminished.

**Ques. 5.84.** What is a "crystal filter" as used in a superheterodyne receiver?

**Ans.** The "crystal filter" is a quartz-plate resonant circuit which has very high  $Q$  characteristics (very sharp tuning). This plate is generally connected between the mixer and first intermediate stages to effect extremely sharp tuning or give so-called "single-signal reception."

**Ques. 5.85.** How may image response be minimized in a superheterodyne receiver?

**Ans.** Image response may be minimized by the introduction of specially designed trap circuits or by adding a pre-selector stage before the mixer tube.

**Ques. 5.86.** Discuss the advantages and disadvantages of a self-excited oscillator and a master-oscillator power-amplifier transmitter.

**Ans.** The advantage of the self-excited oscillator transmitter is that only a single tube is required. The great disadvantage compared to the master-oscillator power-amplifier (MOPA) type is the frequency instability of the self-excited oscillator. Antenna-load changes produce variations in output frequency to such a degree that the output frequency may drift over thousands of cycles.

**Ques. 5.87.** Draw a simple diagram of a dynatron oscillator using a tetrode, indicating polarity of power-supply voltages.

*Ans.* Figure 3-11 illustrates a schematic diagram of a dynatron oscillator.

**Ques. 5.88.** What is the meaning of "carrier shift"?

*Ans.* "Carrier shift" is the unequal relationship of the positive and negative peaks of the modulated wave, which results in a carrier shift. It is due to the lack of symmetry of the modulation envelope, which causes a change in the average amplitude of the modulated wave. (See Ques. 6.42.)

**Ques. 5.89.** What effect upon the plate current of the final-amplifier stage will be observed as the antenna circuit is brought into resonance?

*Ans.* The direct-current plate milliammeter will show an increased reading.

**Ques. 5.90.** What will be the effect of a swinging antenna upon the output of a self-excited oscillator transmitter? A master-oscillator power-amplifier transmitter?

*Ans.* A swinging antenna will cause frequency instability in a self-excited oscillator. When a master-oscillator power-amplifier transmitter is used a swinging antenna will not affect the frequency of the transmitter because the antenna-capacity changes are not reflected back to the oscillator circuit. The radio-frequency power amplifier serves to isolate the oscillator from the antenna circuit. Hence, any capacity changes in the antenna cannot affect the frequency of the oscillator.

**Ques. 5.91.** Discuss the advantage and disadvantage of operating an amplifier as a class C stage.

*Ans.* The advantage is high efficiency. The efficiency of a class C amplifier may be brought up as high as 85 per cent in

practice. Perhaps the only disadvantage of this type of amplifier is the relatively larger excitation voltages required to overcome the large grid-bias voltage used. Also, its output is not so linear as class B.

**Ques. 5.92.** What is the crystal frequency of a transmitter having three doubler stages and an output frequency of 16,880 kilocycles?

*Ans.* Three doubler stages will raise the crystal frequency 8 times, therefore the fundamental crystal frequency must be  $\frac{1}{8}$  of 16,880 or 2,110 kilocycles.

**Ques. 5.93.** What is the ratio of the frequencies of the output and input circuits of a single-phase full-wave rectifier?

*Ans.* The ripple ratio is 2:1. (60-cycle input is raised to a 120-cycle output).

**Ques. 5.94.** What type of energy is obtained from shock excitation of a circuit?

*Ans.* Highly damped oscillations.

**Ques. 5.95.** What increase in antenna current will be noted when a transmitter is modulated 100 per cent by a sinusoidal audio frequency?

*Ans.* An increase of 1.225 times.

**Ques. 5.96.** What may be the reasons why a zero reading is not obtained on the neutralizing indicator while neutralizing a radio-frequency amplifier stage?

*Ans.* This may be due to some tube losses thereby preventing an exact phase balance. A series resistance is sometimes inserted in series with the neutralizing condenser in order to obtain an exact balance or a phase angle of 90 degrees. Stray couplings between the circuits may also prevent a zero reading.

**Ques. 5.97.** What precautions should be observed in tuning a transmitter?

*Ans.* Care should be exercised in adjusting all high-voltage circuits to avoid shock. The high-voltage switch must be opened whenever making coil-tap or condenser-section changes. Filter condensers not shunted by a resistor should be discharged by short-circuiting with insulated-handle screw-driver.

**Ques. 5.98.** Describe a procedure which would be satisfactory in neutralizing a radio-frequency stage.

*Ans.* Open the plate-supply switch to the radio-frequency stage to be neutralized. Open up the main power switch to all tubes, and discharge all high-voltage condensers. Insert a thermocoupled galvanometer into the low potential side of the plate-tank circuit of the stage to be neutralized. Engage the neutralizing condenser about one-third position. Close the main power switch but leave the plate-supply switch of the amplifier open. Increase the radio-frequency drive gradually and tune all circuits to resonance. Observe the reading on the thermocouple galvanometer and vary the neutralizing condenser until this reading is a minimum or, preferably, zero. Remove the thermocouple galvanometer and insert the regular ammeter. Close the high-voltage plate-supply switch to the radio-frequency amplifier just neutralized. Carefully recheck and balance all circuits to minimum plate-current dips.

**Ques. 5.99.** Name three instruments which may be used as indicating devices in neutralizing a radio-frequency amplifier stage.

*Ans.* A thermo galvanometer, a sensitive hot-wire ammeter, a cathode-ray oscilloscope, a neon tube, or a wavemeter.

**Ques. 5.100.** Describe a means of reducing the sparking at the contacts of a key used in a radiotelegraph transmitter.

**Ans.** A condenser shunted across the contacts. A condenser with series resistance shunted across the contacts or a choke coil in series with a condenser shunted across the contacts. See Fig. 5-2.

**Ques. 5.101.** How may instruments used to indicate various direct currents and voltages in a transmitter be protected against damage due to stray radio-frequency energy?

**Ans.** Instruments may be protected by grounding the cases (if metal), shielding the leads and grounding, shunting a small radio-frequency by-pass condenser across them, inserting small radio-frequency chokes and by-pass condensers in the leads, and by placing the meters (ammeters) in the low potential side of the circuit.

**Ques. 5.102.** What is the purpose of the choke coil?

**Ans.** The choke coil in direct-current circuits serves to filter the power supply. The choke coil in radio-frequency circuits serves to isolate the radio-frequency currents from the power-supply circuits. The primary function of a choke coil is to filter or smooth out current variations.

**Ques. 5.103.** What currents will be indicated by a milliammeter connected between the center tap of the filament transformer of a tetrode, and negative high voltage (ground)?

**Ans.** The milliammeter in this position will read the combined plate and screen-grid currents.

**Ques. 5.104.** What emergency repairs may be made to an inductance coil having burned or charred insulation?

**Ans.** The charred or burned portions may be painted with an insulating varnish or liquid colloid provided both types of materials have low dielectric losses. If possible, the defective insulation should first be removed before applying the new insulation. Reduce operating voltage if possible.

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 5.105.** Name four indications of a defective vacuum tube in a transmitter.

*Ans.* Low plate currents under normal filament and plate operating voltages, low tank currents, low antenna currents, blue glow inside envelope between grid and plate, and filament not lighting.

**Ques. 5.106.** What is the purpose of an air gap in the core of a filter choke coil?

*Ans.* An air gap increases the reluctance of the core, thereby reducing the flux density so that it will not be saturated by the rated flow of direct current. The gap in a swinging choke may be only a few thousandths of an inch wide.

**Ques. 5.107.** What are some uses of a low-pass filter network?

*Ans.* A low-pass filter network passes freely all frequencies below a certain point and attenuates all those above this value. This type of network is used in power-supply filter systems for transmitters and receivers. This type of filter is also used in special types of amplifying circuits where it is desired to amplify only a small band of low frequencies. Line noises and highly damped power-line surges may be attenuated by a low-pass type of filter.

**Ques. 5.108.** What is a "swinging choke"?

*Ans.* A choke coil designed to operate with varying loads is commonly referred to as a "swinging choke." The swinging action is obtained by providing an extremely small air gap which allows saturation with a heavy current flow. (See Ques. 2.242.)

**Ques. 5.109.** Indicate the approximate values of power-supply filter inductances encountered in practice.

*Ans.* The maximum value of choke coils generally found in power filters is in the vicinity of 30 henrys. The limiting

factor is generally the direct-current resistance and its consequent voltage drop. The average current requirement is .15 amperes. Average d-c resistance range is 200 to 600 ohms.

**Ques. 5.110.** Why is the core of a transformer made of sheets of iron rather than a solid piece of iron?

*Ans.* To reduce eddy-current losses.

**Ques. 5.111.** What factors determine the eddy-current losses in a transformer?

*Ans.* The character of the core material, the thickness of core laminations, and flux density.

**Ques. 5.112.** Name the losses which are present in transformers.

*Ans.* Eddy-current losses, hysteresis losses, air-gap losses, and copper losses.

**Ques. 5.113.** What factors determine the hysteresis losses in a transformer?

*Ans.* These losses are determined by flux density, the character of the magnetic material, and the operating frequency.

**Ques. 5.114.** What is the secondary voltage of a transformer which has a primary voltage of 100, primary turns 200, and secondary turns, 40?

*Ans.* The secondary voltage is 20 volts.

$$E_s = \frac{N_s}{N_p} \times E_p = \frac{40}{200} \times 100 = 20 \text{ volts.}$$

**Ques. 5.115.** Why should emery cloth never be used to clean the commutator of a motor or generator?

*Ans.* Emery cloth contains metallic ingredients. Possible short circuits might develop.

## *RADIO OPERATING QUESTIONS AND ANSWERS*

**Ques. 5.116.** When increased output voltage is desired from a motor-generator set what is the usual procedure?

*Ans.* The output voltage is increased by strengthening the current through the generator field. This is done by decreasing the resistance in the generator-field rheostat.

**Ques. 5.117.** What will be the effect(s) of a short circuit in an armature coil in a direct-current motor?

*Ans.* Sparking will develop around the commutator and the speed under load will be reduced.

**Ques. 5.118.** When starting a direct-current motor-generator set, what adjustment should be made to the motor field?

*Ans.* The motor-field rheostat should be decreased to minimum resistance.

**Ques. 5.119.** What may be the trouble if a motor generator fails to start when the starter button is depressed?

*Ans.* Blown fuse, open armature, defective starter, open field.

**Ques. 5.120.** What load conditions must be satisfied in order to obtain the maximum possible output from any power source?

*Ans.* Maximum power is obtained when the load resistance matches the internal resistance of the source.

**Ques. 5.121.** Explain the principle of operation of an electrolytic condenser.

*Ans.* The electrolytic condenser functions upon the principle of unilateral conductivity, that is, the condenser offers a very high resistance to current flow in one direction and low resistance to the flow of current in an opposite direction. This type of condenser depends for its operation upon the fact

that certain metals when used as anodes in certain electrolytes become coated with a very thin film of insulation, caused by polarization. This film acts as a dielectric separating the two electrodes constituting the condenser.

**Ques. 5.122.** Why are bleeder resistances used in power supplies?

*Ans.* Bleeder resistors are used in filter circuits across condensers to equalize the charge and remove the strain upon the condensers. They are also used to stabilize the output voltage from power-supply circuits to the load circuits. The bleeder resistance in voltage-divider systems also permits reservoir action to accommodate increases in plate-current swings to the vacuum-tube plate circuits, improving regulation. Bleeder resistors also function to discharge the condensers after shutdown, thus preventing possible shock to the operator.

**Ques. 5.123.** Why is a condenser sometimes placed in series with the primary of a power transformer?

*Ans.* A condenser is very seldom, if ever, placed in series with the primary winding of a power transformer. If a condenser should be used in this manner it would be done for the purpose of resonating the secondary circuit with the primary or, possibly, for controlling the primary reactance to control the current flow. This arrangement might also be used for boosting the primary voltage.

**Ques. 5.124.** What factors determine the breakdown voltage rating of a condenser?

*Ans.* The character of the dielectric and the thickness of the dielectric.

**Ques. 5.125.** What is the effect of low temperatures upon the operation of a lead-acid storage cell?

## *RADIO OPERATING QUESTIONS AND ANSWERS*

*Ans.* Low temperatures temporarily decrease both the discharge voltage and the ampere-hour capacity which can be taken out of the cell.

**Ques. 5.126.** Why should the tops of the lead-acid cell or batteries be kept free from moisture?

*Ans.* To prevent leakage losses and terminal corrosion.

**Ques. 5.127.** How may the condition of charge of an Edison cell be determined?

*Ans.* By the use of a high-resistance voltmeter test under load.

**Ques. 5.128.** What special precautions should be taken when lead-acid cells are subject to low temperatures?

*Ans.* They should be given frequent charging in order to keep the discharge voltage and ampere-hour capacity as high as possible. The cells should be kept on continuous trickle.

**Ques. 5.129.** What should be done if the electrolyte in a lead-acid cell becomes low due to evaporation?

*Ans.* Refill with chemically pure water.

**Ques. 5.130.** What precautions should be used when an absorption type of frequency meter is used to measure the output of a self-excited oscillator?

*Ans.* Place the instrument as far as possible from the circuit being measured to avoid mutual coupling reactions which would alter the output frequency.

**Ques. 5.131.** What is the meaning of "zero beat" as used in connection with frequency-measuring equipment?

*Ans.* "Zero beat" is that condition which prevails when two radio-frequency oscillators are coupled to each other and adjusted to exactly the same frequency. An audible output

circuit, such as headphones, would produce no response under this condition.

**Ques. 5.132.** What precautions should be taken before using a heterodyne type of frequency meter?

*Ans.* The heterodyne-frequency meter should be placed as far as possible from the circuit being checked. The calibration should be checked against a known standard-frequency calibrator. Allow meter time to warm up.

**Ques. 5.133.** If a wavemeter, having a deviation inversely proportional to the wavelength, is accurate to 20 cycles, when set at 1,000 kilocycles, what is its error when set at 1,250 kilocycles?

*Ans.* The error at 1,250 kilocycles will be 25 cycles.

**Ques. 5.134.** What cleaning agents may be used to clean the surfaces of a quartz crystal? Is such cleaning ever necessary? Explain.

*Ans.* The best cleaning agent is carbon tetrachloride (Carbona). Alcohol or plain soap and water may be used. All quartz crystals should be cleaned whenever handled because any oily deposit or grit may prevent the unit from functioning.

**Ques. 5.135.** Name four advantages of crystal control over tuned circuit oscillators.

*Ans.* 1. Maximum frequency stability.  
2. Minimizes dynamic instability  
3. Gives better tone signal for radio telegraphy.  
4. Reduces necessary band width.  
5. Simplifies grid circuit.  
6. Reduces beat frequency of stations on same frequency.

**Ques. 5.136.** Why is a separate source of power desirable for crystal-oscillator units in a transmitter?

## *RADIO OPERATING QUESTIONS AND ANSWERS*

*Ans.* Common power supply for crystal- and power-amplifier units would produce frequency modulation and consequent serious frequency instability and distortion. This is due to load changes upon the oscillator plate circuit which in turn are caused by modulation or power-amplifier plate-load changes.

**Ques. 5.137.** Why is the temperature of a quartz crystal maintained constant?

*Ans.* Because the crystal possesses a temperature coefficient. Temperature changes will cause drifting of the crystal frequency.

**Ques. 5.138.** What will be the effect of a high degree of coupling between the plate and grid circuits of a quartz-crystal oscillator?

*Ans.* Excessive strain may be applied to the crystal and a possible cracking or chipping may result.

**Ques. 5.139.** What is the function of a quartz crystal in a radio transmitter?

*Ans.* The crystal serves as the frequency controlling unit of the oscillator to maintain a station at a critical frequency. It is the frequency stabilizer of the transmitting system.

**Ques. 5.140.** What does the expression "low temperature coefficient crystal" mean?

*Ans.* This term means that the variation in crystal frequency with positive and negative change in temperature is practically zero.

**Ques. 5.141.** What does the expression "the temperature coefficient of an X-cut crystal is negative" mean?

*Ans.* "A negative coefficient characteristic" is one in which the crystal frequency decreases as the temperature is raised.

**Ques. 5.142.** What will be the effect of applying a direct-current potential to the opposite plane surfaces of a quartz crystal?

*Ans.* The crystal will change in shape, the amount and direction of the change depending upon the cut of the crystal.

**Ques. 5.143.** What does the expression "the temperature coefficient of a Y-cut crystal is positive" mean?

*Ans.* "A positive coefficient characteristic" is one in which the crystal frequency increases as the temperature is raised.

**Ques. 5.144.** Draw a simple schematic diagram of a crystal-controlled oscillator using a tetrode-type tube. Indicate power-supply polarity where necessary.

*Ans.* Figure 2-10 illustrates a schematic diagram of a tetrode crystal oscillator. The basic circuit is the same as that using a pentode tube with the exception that the suppressor grid (next to the plate) is omitted.

**Ques. 5.145.** What is a "multivibrator"? Explain the principle of operation.

*Ans.* The multivibrator or relaxation oscillator is a two-tube resistance-coupled oscillator in which the voltage developed by the output of the second tube is applied to the input of the first tube. The principle of operation is based upon the fact that the tubes invert the wave form. The output wave is nonsinusoidal in character. This type of oscillator may be used for any of the following purposes:

1. Master oscillator timer.
2. To produce rectangular control pulses of certain lengths, synchronized with excitation trigger pulses.
3. To introduce delay between input trigger pulses and a second circuit.
4. Frequency division. To synchronize or lock circuits at other than 1:1 ratio.

**Ques. 5.146.** What is a dynatron oscillator? Explain its principle of operation.

*Ans.* A dynatron oscillator is a tetrode oscillator in which the screen-grid voltage is operated at a critical point above the plate-voltage potential. It operates upon the principle of the *negative resistance* characteristic used in regeneration and oscillatory circuits. As the plate voltage is gradually raised, the plate to cathode current is reduced, owing to a neutralizing effect at some critical point between the normal emission from the cathode and the secondary emission from the plate. When this particular point is reached, the plate-to-filament resistance will indicate a negative-resistance characteristic and the plate-tank circuit will continue to oscillate.

**Ques. 5.147.** What is an electron-coupled oscillator? Explain its principle of operation.

*Ans.* The electron-coupled oscillator is a tetrode oscillator in which the control grid, cathode, and screen grid serve as the triode section of an oscillator. The screen grid serves as the oscillator plate. The regular plate is coupled through the tube capacity to the triode elements. The variation of the space charge is controlled by the triode grid and these variations in turn energize the plate circuit and its load impedance.

**Ques. 5.148.** Explain the principle of generation of radio-frequency energy by means of a spark discharge.

*Ans.* (See Ques. 3.146.)

**Ques. 5.149.** Explain the principle of generation of radio-frequency energy by means of an electric arc.

*Ans.* When the arc is struck the high-potential current across the terminals begins to charge the condenser, which is made up of the antenna and the ground, as shown in Fig. 3-13. This condenser, therefore, takes some of the current away from the arc. Hence, the voltage across the arc increases until the condenser is fully charged.

When the condenser is fully charged, the current through the arc rises to normal value. This causes the voltage across the arc to drop. The condenser, however, is still fully charged and

its voltage value is now higher than that of the arc. The condenser, therefore, discharges across the arc. Because the discharge takes place through a circuit having oscillatory characteristics, undamped or continuous wave oscillations are produced.

At each oscillation the voltage rises and falls periodically, giving a constant source of energy to the condenser.

In order to signal with this system, it is necessary to provide some means of breaking up the continuous oscillations into code groups.

**Ques. 5.150.** Draw a simple schematic diagram of a crystal-controlled oscillator and means of coupling to the following radio-frequency amplifier stage, showing power-supply polarities.

*Ans.* See Fig. 4-13..

**Ques. 5.151.** Draw a simple schematic diagram of an oscillatory circuit involving the use of a spark-gap discharge, indicating the circuit elements necessary to identify this form of oscillatory circuit.

*Ans.* See Fig. 3-12.

**Ques. 5.152.** Draw a simple schematic diagram of an electron-coupled oscillator, indicating the circuit elements necessary to identify this form of oscillatory circuit.

*Ans.* See Fig. 2-9.

**Ques. 5.153.** Draw a simple schematic diagram of a dynatron type of oscillator, indicating the circuit elements necessary to identify this form of oscillatory circuit.

*Ans.* See Fig. 3-11.

**Ques. 5.154.** Draw a simple schematic diagram of an oscillating-arc circuit, indicating the circuit elements necessary to identify this form of oscillatory circuit.

*Ans.* See Fig. 3-13.

## *RADIO OPERATING QUESTIONS AND ANSWERS*

**Ques. 5.155.** Why is a push-pull audio-frequency amplifier preferable to a single-tube stage?

*Ans.* A push-pull audio-frequency amplifier is preferable to a single-tube stage because by means of the push-pull circuit the even harmonics in the output are neutralized. A greater power output is also secured from a push-pull amplifier than is secured from a single-tube amplifier.

**Ques. 5.156.** Name four applications for vacuum tubes operating as class A audio amplifiers.

*Ans.* Four applications of vacuum tubes operating as class A audio amplifiers are as follows:

1. Audio-frequency voltage amplifiers in receivers.
2. Audio-frequency voltage amplifiers in speech input equipment.
3. Modulators.
4. Line amplifiers.
5. Microphone pre-amplifiers.
6. Audio-frequency power amplifiers in receivers.

**Ques. 5.157.** What is the chief advantage of class A audio operation as compared to other classes of audio-frequency amplifiers?

*Ans.* The chief advantage of class A audio operation is that the output is essentially linear, and distortion is reduced to a minimum. Also, it may be operated with a single-tube.

**Ques. 5.158.** Why is correct grid bias important in an audio-frequency amplifier?

*Ans.* The correct grid bias is important because it serves to locate the operating point of the tube at the proper location on the characteristic curve for the desired operating conditions.

**Ques. 5.159.** How may even harmonic energy be reduced in the output of an audio-frequency amplifier?

*Ans.* Harmonic energy may be reduced in the output of an audio-frequency amplifier by operating the tube with a limited grid-voltage swing so that the plate current is never driven off the straight-line portion of the characteristic. In addition, even harmonic energy may be reduced by working the tubes in a push-pull circuit, thus canceling out the even harmonics.

**Ques. 5.160.** Why are class A audio amplifiers not as critical, insofar as grid-drive requirements are concerned, as class B audio amplifiers?

*Ans.* Because plate current flows during the entire excitation cycle. Therefore, as long as an excitation voltage is present an output component will be secured. On the other hand, with a class B audio amplifier the excitation voltage must be of the correct value within limits to cause the tube to operate on the desired portion of the grid-voltage plate-current characteristic. (See also Ques. 3.166.)

**Ques. 5.161.** Name at least two uses of a class C radio-frequency amplifier in modern radiotelegraph and radiotelephone transmitters.

*Ans.* A class C radio-frequency amplifier may be used in the transmitting circuit as follows:

1. As a buffer amplifier.
2. As a power amplifier for class C telegraphy.
3. As a frequency multiplier (usually a doubler).
4. As a modulated radio-frequency amplifier.

**Ques. 5.162.** Name four causes of excessive plate current in a radio-frequency amplifier.

*Ans.* Excessive plate current may be caused in the radio-frequency amplifier by any of the following:

1. Plate circuit not tuned to resonance.
2. Parasitic oscillations.
3. Improper neutralization.
4. Excessive excitation voltage.

5. Defective vacuum tube.
6. Insufficient bias.

**Ques. 5.163.** What is the chief advantage of a class B radio-frequency amplifier, and for what is this type of amplifier commonly employed?

*Ans.* The chief advantage of a class B radio-frequency amplifier is its linearity of operation. It is, therefore, commonly used as a final power radio-frequency amplifier or as a power amplifier following a modulated class C amplifier.

**Ques. 5.164.** What class of amplifier should be used following a modulated radio-frequency amplifier?

*Ans.* A class B radio-frequency power amplifier.

**Ques. 5.165.** Define a class C amplifier.

*Ans.* A class C amplifier operates with a grid bias, which is appreciably greater than the cut-off value. The plate current in each tube is zero when no alternating grid voltage is applied. The plate current in a specific tube flows for appreciably less than one-half of each cycle when an alternating grid voltage is applied. (I.R.E. definition, 1938.)

**Ques. 5.166.** Why are by-pass condensers used across the cathode-bias resistors of a radio-frequency amplifier?

*Ans.* By-pass condensers are used across the cathode bias resistors of a radio-frequency amplifier to provide a low reactance path for the alternating plate component to return to the filament. This reduces degeneration and increases the stage gain.

**Ques. 5.167.** What is the main advantage of a tuned audio-frequency amplifier in a receiver used for the reception of radiotelegraph signals?

*Ans.* The main advantage of a tuned audio-frequency amplifier in a receiver used for C-W reception is that with a

tuned audio-frequency amplifier the receiver will respond to only one frequency. It is possible, therefore, to decrease interference by filtering out unwanted signals near the frequency to which the receiver is tuned.

**Ques. 5.168.** What is the purpose of decoupling networks in the plate circuits of a multistage audio amplifier?

*Ans.* When the plate voltage for several tubes of a high-gain amplifier is obtained from a single source, decoupling networks are used to prevent the internal resistance of the power source from acting as a coupling between stages. These circuits also prevent the coupling of the stages through bleeder circuit resistors when screen voltage for two or more tubes is taken from a common tap or through a bias resistor common to the control-grid circuits of several tubes.

**Ques. 5.169.** What is a "buffer" amplifier and what are its applications?

*Ans.* The purpose of the buffer amplifier is to isolate the oscillator from the succeeding stages of radio-frequency amplification. This prevents any reaction between the modulated radio-frequency amplifiers and the oscillator, which might cause frequency instability.

**Ques. 5.170.** For what purpose is a frequency-doubler stage used in a transmitter?

*Ans.* The doubler amplifier is used when an output frequency greater than the maximum safe operating frequency of a crystal oscillator is desired.

**Ques. 5.171.** Describe the operation of a frequency-doubler stage.

*Ans.* See Fig. 2-26 for diagram. The tube is biased beyond the cut-off point. This causes a distorted wave shape in the plate circuit. The plate  $L-C$  circuit is tuned to twice the input

frequency with the result that strong harmonic voltages are set up in it by the distorted wave shape before referred to.

**Ques. 5.172.** Why is neutralization generally necessary in a radio-frequency amplifier?

*Ans.* Neutralization is generally necessary in a radio-frequency amplifier to prevent erratic operation of the circuit which would occur if the amplifier went into self-oscillation owing to feedback. Neutralization prevents feedback.

**Ques. 5.173.** What is the purpose of shielding between radio-frequency amplifier stages?

*Ans.* The purpose of shielding in a multistage radio receiver is to prevent electrical interaction between the various receiver components, which interaction would disturb their normal operation. Shielding prevents the lines of force surrounding the shielded component from leaving the area within the shield. Shielding also prevents any outside lines of force from entering the shielded compartment.

**Ques. 5.174.** Describe how a radio-frequency amplifier stage may be neutralized.

*Ans.* Open the plate-supply switch to the radio-frequency stage to be neutralized. Open up the main power switch to all tubes and discharge all high-voltage condensers. Insert a thermocouple galvanometer into the low potential side of the plate-tank circuit of the stage to be neutralized. Engage the neutralizing condenser about one-third position. Close the main power switch, but leave the plate-supply switch of the amplifier open. Increase the radio-frequency drive gradually and tune all circuits to resonance. Observe the reading on the thermocouple galvanometer and vary the neutralizing condenser until this reading is a minimum or, preferably zero. Remove the thermocouple galvanometer and insert the regular ammeter. Close the high-voltage plate-supply switch to the

radio-frequency amplifier just neutralized. Carefully recheck and balance all circuits to minimum plate-current dips.

**Ques. 5.175.** In neutralizing a radio-frequency amplifier stage of a transmitter, using a thermocouple galvanometer as indicator, what precautions must be observed?

*Ans.* When a thermocouple meter is used as an indicator care must be taken not to burn the meter out. To prevent this, the thermocouple should be inserted in a pick-up loop, which, in turn, can be loosely coupled to the tank circuit of the amplifier stage being neutralized.

**Ques. 5.176.** Draw a complete schematic diagram of a system of inductive coupling between the output of a radio-frequency amplifier and an antenna system.

*Ans.* See Fig. 2-19.

**Ques. 5.177.** Draw a simple schematic diagram showing a method of link coupling between two radio-frequency amplifier stages.

*Ans.* See Fig. 3-9.

**Ques. 5.178.** Draw a simple schematic diagram showing a method of direct coupling between two stages of an audio-frequency amplifier.

*Ans.* See Fig. 3-16.

**Ques. 5.179.** Draw a simple schematic diagram showing a method of impedance coupling between two stages of a radio-frequency amplifier.

*Ans.* See Fig. 3-15.

**Ques. 5.180.** Draw a simple schematic diagram showing a method of inductive or transformer coupling between two stages of a radio-frequency amplifier.

*Ans.* See Fig. 2-20.

**Ques. 5.181.** Discuss the characteristics of a dynatron oscillator.

*Ans.* The characteristics of a dynatron type of oscillator are as follows:

1. A well-designed dynatron has a frequency stability which compares favorably with that of the crystal oscillator without temperature control.

2. Its efficiency is low.

3. It can be used in a heterodyne wavemeter. When so used, the sharpness of indication of the meter is increased because the dynatron neutralizes the positive resistance of the wavemeter circuit. This it does by virtue of the negative resistance of the tube operating as a dynatron.

**Ques. 5.182.** What type of oscillator depends upon secondary emission from the anode for its operation?

*Ans.* The dynatron oscillator.

**Ques. 5.183.** What is the primary reason for the suppression of radio-frequency harmonics in the radio-frequency output of a transmitter?

*Ans.* To prevent interference on other channels, which are in harmonic relation to the fundamental frequency being transmitted.

**Ques. 5.184.** In a radiotelegraph transmitter employing a direct-current generator as a source of plate voltage, an alternating-current generator as filament supply and grid-bias keying, if it is noted that when the key contacts are open the emission continues, what could be the trouble?

*Ans.* This would indicate that no blocking bias is being applied to the tubes. This might be caused by a burned-out bias resistor or a defect in the bias circuit. It might also be due to a short-circuited key-click condenser, the relay key contacts may have stuck, or the relay key may be defective.

**Ques. 5.185.** What is the purpose of an electrostatic shield?

**Ans.** An electrostatic shield, also known as a Faraday screen, is used between the plate-tank coil of the final radio-frequency power amplifier and the antenna coil coupled to it. The purpose of this shield is to reduce the radiation of harmonic energy. This it does by effectively loosening the coupling between the two coils and providing a low-reactance path to ground for the harmonic frequencies.

**Ques. 5.186.** What is the advantage of link coupling between radio-frequency amplifier stages?

**Ans.** Link coupling reduces the radiation of harmonic frequencies. Another advantage of link coupling is that it permits the construction of the various amplifier stages as separate units, these units being effectively coupled by a low impedance line with coupling loops, consisting of one or two turns of wire, at each end, known as the link circuit.

**Ques. 5.187.** Draw a simple schematic diagram showing how a radiotelegraph transmitter may be keyed by the grid-blocking method.

**Ans.** See Fig. 5-1.

**Ques. 5.188.** By what means may a high-power radiotelegraph transmitter be keyed?

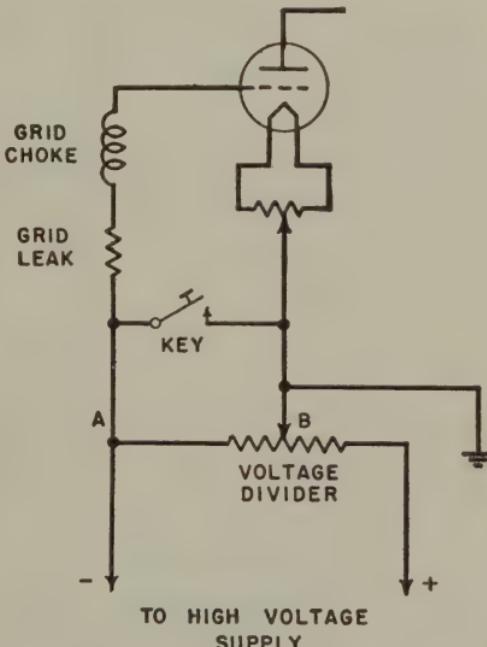


FIG. 5-1.—Grid-blocking keying system.

*Ans.* The most satisfactory means of keying a high-power radiotelegraph transmitter is by the so-called grid-blocking system. With this system a grid bias sufficient to block the power amplifier is applied when the key is up. The key is connected to shunt the bias resistor, thus removing the bias when the key is down. When the bias is removed, the signal wave is emitted by the transmitter.

Another system is the grid-choke method. In this system a choke heavy enough to stop oscillation of the tube is placed in the grid of the oscillator tube and known as a "keying choke." This choke is short-circuited when the key or keying-relay contacts are closed which permits the tube to oscillate; hence, keying is accomplished.

In connection with crystal-controlled transmitters, it is generally undesirable to key the oscillator or the buffer amplifier, as to do so would disturb the frequency stability of the transmitter. The practice with these transmitters is to key the stages following the buffer amplifier, usually by the grid-blocking system.

**Ques. 5.189.** What is meant by "grid block keying"?

*Ans.* (See preceding answer.)

**Ques. 5.190.** Draw a simple schematic diagram of a key-click filter suitable for use when a vacuum-tube transmitter is keyed in the negative high-voltage circuit.

*Ans.* See Fig. 5-2.

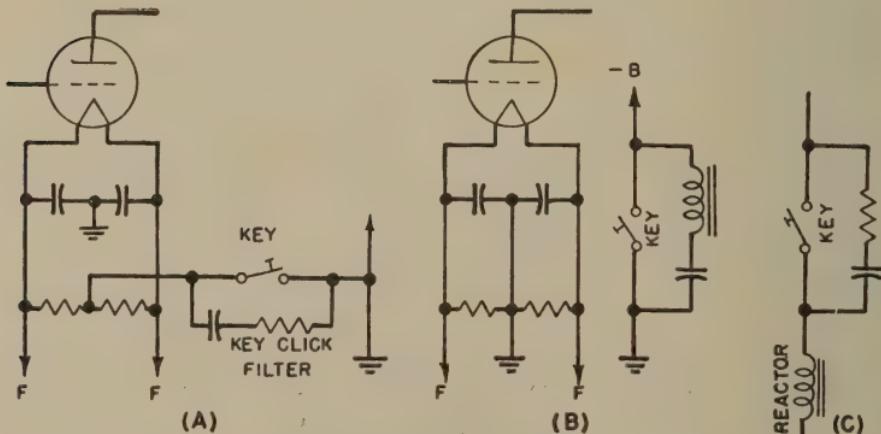


FIG. 5-2.—Key-click filters.

**Ques. 5.191.** Draw a simple schematic diagram of a system of keying in the primary of the transformer supplying high voltage to a vacuum-tube transmitter. Indicate any values of inductance, resistance, capacitance which may be deemed necessary to fully understand the correct operation of this type of keying.

*Ans.* See Fig. 5-3.

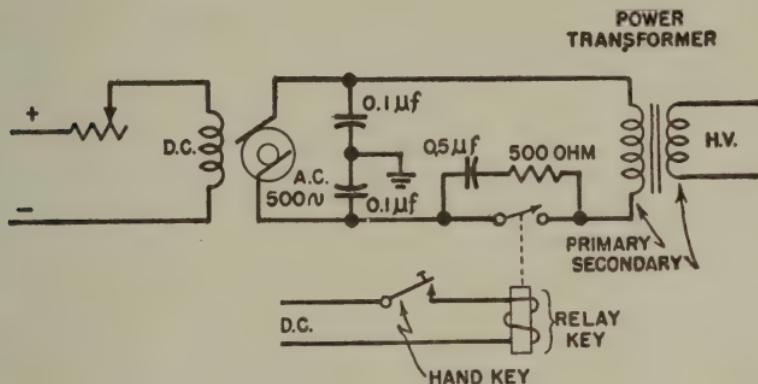


FIG. 5-3.—Transformer-primary keying system.

**Ques. 5.192.** A transmitter is operating on 5,000 kilocycles, using a 1,000-kilocycle crystal with a temperature coefficient of  $-4$  cycles/megacycle/degree centigrade. If the crystal temperature increases 6 degrees centigrade, what is the change in the output frequency of the transmitter?

*Ans.* 4,999.88 kilocycles is the new frequency.

**Ques. 5.193.** What may cause a positive carrier shift in a linear radio-frequency amplifier output?

*Ans.* Some possible causes of positive carrier shift are:

1. Improper neutralization.
2. Excessive grid bias.
3. Improper value of load impedance.
4. Overmodulation.
5. Insufficient excitation of modulated tube(s).  
(See Ques. 6.42.)

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 5.194.** What is the second harmonic of 380 meters?

*Ans.* 190 meters.

**Ques. 5.195.** What is the effect of excessive coupling between the output circuit of a simple oscillator and an antenna?

*Ans.* Excessive coupling will cause what is known as a "split tuning." The load impedance coupled to the oscillator is an equivalent impedance which is the resultant of the impedances of the closed- and open-oscillatory circuits. It is impossible to keep both of these impedances exactly alike. Changes in tube constants during operation vary the impedance of the closed-oscillatory circuit, while changes in antenna capacity, caused by antenna movement, vary the impedance of the open-oscillatory circuit. If the coupling is tight, the difference between these two impedances is enough to present a broad or "two humped" load-impedance characteristic to the tube. However, it chooses the lowest impedance. If the lowest value shifts from one circuit to the other, the frequency jumps with the shift. Split tuning can be avoided by using a loose coupling adjustment, although it must be borne in mind that loosening the coupling also reduces the radiated power. The plate current will rise and may seriously overheat the tube if coupling is too tight.

**Ques. 5.196.** A station has an assigned frequency of 8,000 kilocycles and a frequency tolerance of plus or minus 0.04 per cent. The oscillator operates at one-eighth of the output frequency. What is the maximum permitted deviation of the oscillator frequency, in cycles, which will not exceed the tolerance?

*Ans.* 400 cycles, computed as follows:

$$3.2:8,000 = X:1,000; \quad X = 0.4 \text{ kilocycle}; \quad X = \pm 400 \text{ cycles.}$$

**Ques. 5.197.** What is meant by "self-wiping" contacts as used in connection with relays?

*Ans.* "Self-wiping" contacts are contacts which slide together instead of butt together. All modern relays are constructed with self-wiping contacts.

**Ques. 5.198.** Why are permanent magnets used in head telephones? In direct-current meters?

*Ans.* To polarize the headphones so that positive current peaks deflect the diaphragm in one direction while negative peaks deflect it in the opposite direction.

Permanent magnets are used in direct-current meters to insure the operation of the meter according to the polarity markings on its terminals. Permanent magnets, as used in direct-current meters, serve to increase the accuracy of the meter and provide a fixed field which produces a torque in the moving coil in proportion to the current flowing in the coil.

**Ques. 5.199.** What devices may be used as indicators of radio-frequency energy?

*Ans.* The following devices may be used as indicators of radio-frequency energy:

1. Thermocouple galvanometer.
2. Hot-wire ammeter.
3. Neon bulb.
4. Carbon-filament glow lamp.

**Ques. 5.200.** What is the correct value of negative grid bias, for operation as a class B amplifier, for a vacuum tube of the following characteristics : Plate voltage 1,000, plate current 127 milliamperes, filament voltage 4 volts, filament current 5.4 amperes, mutual conductance 8,000 micromhos, and amplification factor 25?

*Ans.* 42 volts, computed as follows:

Cut-off point =  $\frac{Ep}{\mu} = \frac{1,000}{25} = 40$  volts plus one-half the filament voltage equals 42 volts.

**Ques. 5.201. Is an oscillator ever neutralized? Discuss.**

*Ans.* No. Neutralization is used for the purpose of preventing oscillation and the feedback of energy between the plate and grid circuits. As the primary purpose of an oscillator is to oscillate, and as the feedback of energy from the plate to the grid circuit is necessary for oscillation, the oscillator, obviously, is never neutralized.

**Ques. 5.202. What is the definition of "type B" emission?**

*Ans.* The "type B wave" may be defined as a damped wave. A damped wave is one in which the energy decreases progressively with each oscillation until the wave train dies out.

**Ques. 5.203. Define type A1, A2, A3, and A4 emission.**

*Ans.* (See Ques. 4.213)

**Ques. 5.204. In the aerial mobile service, what is the maximum period of time that operation of 333 kilocycles is permitted?**

*Ans.* In no case, in the aeronautical mobile service, must the work on 333 kilocycles (900 meters) exceed 5 minutes.

**Ques. 5.205. Who may authorize tests or experiments by other than mobile stations?**

*Ans.* The FCC inspector in charge of the district in which the transmitter is located.

**Ques. 5.206. What is the maximum period of time during which test V's may be transmitted for purposes of adjusting a transmitter?**

*Ans.* When it is necessary to make test signals, either for the adjustment of a transmitter before transmitting the call, or for the adjustment of a receiver, these signals must not last more than 10 seconds, and they must be composed of a series

of V's followed by the call signal of the station transmitting for the tests.

**Ques. 5.207.** In all cases other than those in which the transmitter output must be maintained at a fixed value, what amount of power should be employed for routine communications?

*Ans.* In all circumstances, except in case of radio communications or signals relating to vessels in distress, all radio stations, including those owned and operated by the United States, shall use the minimum amount of power necessary to carry out the communication desired.

**Ques. 5.208.** What is the radiotelegraph urgent signal?

*Ans.* In radiotelegraphy, the urgent signal shall consist of the group XXX transmitted three times, with the letters of each group, as well as the consecutive groups, well separated; it shall be sent before the call.

**Ques. 5.209.** What is the urgent signal for radiotelegraph use in the aeronautical service?

*Ans.* In the aeronautical service, the urgent signal PAN shall be used in radiotelegraphy and in radiotelephony to indicate that the aircraft transmitting it is in trouble and is forced to land, but that it is not in need of immediate help. This signal should, as far as possible, be followed by a message giving additional information.

**Ques. 5.210.** What is the meaning of the spoken expression MAYDAY?

*Ans.* In radiotelephony, the distress signal shall consist of the spoken expression MAYDAY (corresponding to the French pronunciation of the expression *m'aider*).

**Ques. 5.211.** In radiotelegraphy, what is the safety signal?

*Ans.* In radiotelegraphy, the safety signal shall consist of the group TTT, transmitted three times, with the letters of

## RADIO OPERATING QUESTIONS AND ANSWERS

each group, as well as the consecutive groups, well separated. This signal shall be followed by the word DE and three transmissions of the call signal of the station sending it. It announces that this station is about to transmit a message concerning the safety of navigation or giving important meteorological warnings.

**Ques. 5.212.** What is the maximum transmission speed to be used in connection with distress, emergency, or safety transmissions?

*Ans.* When distress, emergency, or safety is involved, the telegraph transmission speed, in general, must not exceed 16 words per minute.

**Ques. 5.213.** What is the general call "to all" stations?

*Ans.* Two types of call signals "to all" shall be recognized:

1. The CQ call followed by the letter K.
2. The CQ call not followed by the letter K.

**Ques. 5.214.** What is the radiotelephone urgent signal?

*Ans.* In radiotelephony, the urgent signal shall consist of three transmissions of the expression PAN (corresponding to the French pronunciation of the word *panne*); it shall be transmitted before the call.

**Ques. 5.215.** What is the radiotelegraph distress signal?

*Ans.* In radiotelegraphy, the distress signal shall consist of the group ...———... transmitted as one signal, in which the dashes must be emphasized so as to be distinguished clearly from the dots.

**Ques. 5.216.** What classes of stations may be operated by the holder of a radiotelegraph permit?

*Ans.* Any station while using type B, A0, A1, A2, A3, or A4 emission; provided that, in the case of equipment designed for and using type A3 or A4 emission;

1. Such operator is prohibited from making adjustments that may result in improper transmitter operation.

2. The equipment is so designed that none of the operation necessary to be performed during the course of normal rendition of service may cause off-frequency operation or result in any unauthorized radiation.

3. Any needed adjustments of the transmitter which may affect proper operation of the station are regularly made by or in the presence of an operator holding a first- or second-class license, either telephone or telegraph, who shall be responsible for the proper operation of the equipment.

*Exceptions:* 1. The permit is not valid for the operation of any of the various classes of broadcast stations other than a relay broadcast station.

2. The permit is not valid for the operation of a ship station licensed to use type A-3 emission for communication with coastal telephone stations.

3. The license is not valid for the operation of a radiotelegraph station on board a vessel required by treaty or statute to be equipped with a radio installation.

4. The license is not valid for the operation of any ship telegraph, coastal telegraph, or marine-relay station open to public correspondence.

**Ques. 5.217.** For what period of time must a station log, which contains entries incident to a disaster, be retained?

*Ans.* Logs containing distress entries shall be retained by the licensee until specifically authorized by the Commission to destroy them.

**Ques. 5.218.** Define meaning of "frequency tolerance."

*Ans.* The amount of frequency variation allowed under the regulations of the FCC for the particular class of station.

**Ques. 5.219.** Under what circumstances may a station be operated by an unlicensed person?

## *RADIO OPERATING QUESTIONS AND ANSWERS*

*Ans.* The actual operation of all licensed transmitting apparatus must be carried on by a licensed operator. However, it is provided that the Commission, if it finds that the public interest, convenience, or necessity will be served thereby, may waive or modify the provisions requiring the licensed operator, except under certain special conditions, as outlined in Section 318 of the Communications Act of 1934.

**Ques. 5.220.** If an operator is employed at more than one station, how may he comply with the rule requiring the posting of operator licenses?

*Ans.* The holder of an operator license who operates any station in which the posting of an operator license is not required, may, upon filing application in duplicate, accompanied by his license, obtain a verification card. This card may be carried on the person of the operator in lieu of the original operator license, provided the license is readily accessible within a reasonable time for inspection upon demand by an authorized Government representative.

**Ques. 5.221.** If, upon being called by another station, a called station is unable to proceed with the acceptance of traffic, what should the operator of the called station do?

*Ans.* If the station called is prevented from receiving, it shall reply to the call as indicated in the Regulations, but it shall replace the letter K by the signal .— . . . (wait), followed by a number indicating in minutes the probable duration of the wait. If this probable duration exceeds 10 minutes (5 minutes in the aeronautical mobile service), a reason must be given therefor.

**Ques. 5.222.** What is the definition of a "station open to public service"?

*Ans.* A station open to public correspondence at published rates; that is, a paid or toll message service.

**Ques. 5.223.** Under what circumstances may the Commission authorize the remote control of a radiotelegraph transmitter, with the operator at a point other than the location of the transmitter proper?

*Ans.* The Commission may modify the rule requiring an

- operator on duty at the place where the transmitter is located, provided that, upon proper application, a showing is made that such operator or operators may be on duty at the control station in lieu of the place where the transmitting apparatus is located.

In the case of two or more stations, except amateur and broadcast, using frequency above 30,000 kilocycles only, a licensed radio operator of any class, except amateur or holder of restricted radiotelephone or radio telegraph operator permit, who has the station within his effective control, may be on duty at any point within the communication of range of such stations in lieu of the transmitter location or control point during the actual operation of the transmitting apparatus.

**Ques. 5.224.** How is an experimental station restricted with regard to message traffic?

*Ans.* Experimental stations shall not be used to conduct general message traffic of any kind, to demonstrate equipment for prospective sales purposes, to transmit programs for direct entertainment, to transmit the programs of any other station, except in conjunction with experimental programs, or to render any commercial communication service or communications involving advertising, either directly or indirectly, subject to specific limitations and restrictions which will be prescribed in individual cases by the Commission. This authority will be granted only for special reasons to obtain information or data which give promise of being of benefit to the radio art.

**Ques. 5.225.** Describe the procedure of a radiotelegraph transmission in which one station calls another.

## *RADIO OPERATING QUESTIONS AND ANSWERS*

*Ans.* The call shall consist of the following:

1. The call signal of the station called transmitted not more than three times.
2. The word DE.
3. The call signal of the calling station transmitted not more than three times.

**Ques. 5.226.** What is the total reactance when two capacitances of equal value are connected in series?

*Ans.* The reactance value in ohms is doubled.

**Ques. 5.227.** What are the effects of overexcitation of a class B amplifier grid circuit?

*Ans.* Overexcitation of the amplifier grid may cause an excessive value of grid current to flow which may seriously overload the tube and possibly ruin it. The regulation and plate-circuit linearity will be completely lost owing to the loading effect upon the plate current. The plate efficiency will be greatly reduced and the power output correspondingly lowered. Plate dissipation may rise to abnormal values. Harmonic distortion will also be caused by overexcitation. (See also Ques. 5.57.)

**Ques. 5.228.** Name four devices that could be used to indicate oscillation in a crystal oscillator.

*Ans.* A direct-current milliammeter in series with the grid leak of the oscillator; the plate direct-current milliammeter; radio-frequency ammeter in the plate-tank circuit; radio-frequency galvanometer in the grid circuit; a neon tube placed near the grid or plate oscillatory leads; a wavemeter and lamp indicator placed near to the plate-tank circuit.

**Ques. 5.229.** What is the effect of loose laminations in a filter choke?

*Ans.* Loose laminations may produce a chattering or hum. The inductance may also be affected.

**Ques. 5.230.** What is a desirable feature of an electrolytic condenser as compared with other types?

*Ans.* Much greater capacity is obtainable with smaller physical dimensions as compared with other types. A wet type of electrolytic condenser also possesses self-healing properties.

**Ques. 5.231.** Why is an additional plate-grid feedback condenser sometimes necessary in a crystal oscillator?

*Ans.* The feedback condenser is sometimes employed to supply sufficient increment to start the crystal oscillating. This is particularly true where the internal grid-plate capacity of a tube is low, such as with the screen-grid types of tubes. The condenser must, however, be very small since excessive voltage surges to the quartz plate may fracture it.

**Ques. 5.232.** Who may authorize tests or experiments by stations other than mobile stations?

*Ans.* (This is a duplicate of Ques. 5.205.)

## ELEMENT 6

### ADVANCED RADIOTELEGRAPHY

**Ques. 6.01.** What are the ratios between the average, effective, and peak values of a sinusoidal wave?

*Ans.* The various ratios are as follows:

$$\text{Peak to effective} = \frac{1}{0.707} = 1.414:1.$$

$$\text{Peak to average} = \frac{1}{0.637} = 1.57:1.$$

$$\text{Effective to average} = \frac{0.707}{0.637} = 1.11:1.$$

Any of these values may readily be transposed for another desired ratio.

**Ques. 6.02.** Define the following terms: "hysteresis," "permeability," "eddy currents."

*Ans.* "Hysteresis" is the molecular friction produced by the alternating-current reversals in a magnetic-core material. It is the lagging effect of the magnetic flux with respect to the magnetizing force that produces it.

"Permeability" is the ease of magnetic conduction through a magnetic material as compared to air. It is the measure of the relative conductivity of iron or any magnetic material compared with air.

"Eddy currents" are the circulation of small currents through the interior of a solid mass of conducting material. These currents are caused by the generation of small e.m.fs. owing to the movement of a magnetic field near a material or

the movement of the material itself in a magnetic field. These currents as set up are similar to swirls of water in their motion with respect to the flow of water which is causing them. Hence the term "eddy currents."

**Ques. 6.03.** What is the total impedance of a series alternating-current circuit having an inductive reactance of 14 ohms, a resistance of 6 ohms, and a capacitive reactance of 6 ohms?

*Ans.* The impedance is 10 ohms.

**Ques. 6.04.** What is the total impedance of a series alternating-current circuit having an inductive reactance of 14 ohms, a resistance of 6 ohms, and zero capacitive reactance.

*Ans.* The total impedance is 15.2 ohms.

**Ques. 6.05.** What changes in circuit constants will double the resonant frequency of a resonant circuit?

*Ans.* By halving the inductance and the capacitance values or dividing the LC value by 4.

**Ques. 6.06.** How may the *Q* of a parallel resonant circuit be increased?

*Ans.* The *Q* of a parallel resonant circuit is determined by the ratio,  $\frac{2\pi fL}{R}$ . Increasing the *Q* is generally accomplished practically by reducing the resistance and absorption losses of the coil and circuit by reducing the radio-frequency resistance of the coil and leads. In addition, by the use of special low-loss dielectric supporting forms made from materials such as quartz, isolantite, micalex, and so forth for both coils and tuning condensers. These are the general considerations for increasing the *Q* of oscillatory circuits although such factors as core material and mutual coupling must also be considered in changing the *Q*, the figure of merit for efficiency.

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 6.07.** If a parallel circuit, resonant at 1,000 kilocycles, has its values of inductance halved and capacity doubled, what will be the resonant frequency?

*Ans.* 1,000 kilocycles.

**Ques. 6.08.** Assume a resistance of 8 ohms in parallel with a resistance of 6 ohms: in series with this combination is a resistance of 77 ohms. What is the total resistance of the combination?

*Ans.* Reducing the parallel combination to its effective resistance we obtain,  $R_{eff} = \frac{R_1 \times R_2}{R_1 + R_2} = 3.42$  ohms.

Thus,  $R_3 + R_{eff} = 80.42$  ohms.

**Ques. 6.09.** Assume an inductance of 5 henrys in parallel with a capacitance of 1 microfarad. If there is no resistance in either leg of this circuit, what is the equivalent impedance of the parallel network at resonance?

*Ans.* The impedance looking into the network at resonance will be theoretically infinite. This may be seen from the parallel-resonance impedance equation,

$$Z = \frac{X_L^2}{R} \text{ ohms.}$$

As the denominator in the equation is reduced, the impedance rises. The impedance of the combination inside the circulating network will, on the other hand, be zero.

**Ques. 6.10.** Why are iron cores, of the type used in audio-frequency transformers, not used in radio-frequency transformers?

*Ans.* There are two primary reasons why this is not done:

1. The iron cores as used in audio-frequency transformers would present hysteresis and eddy-current losses of too high a value to allow practical efficiencies. Dust cores of iron and alloys have been successfully used at low radio frequencies.

2. Radio-frequency transformers generally respond to a narrow band of radio frequencies. They must possess selective qualities in order to effect sharp tuning. Large iron cores would defeat this purpose. The iron cores such as are used in audio transformers permit a broad-frequency response to enable the passage of the speech and musical frequencies. This range for the average audio-frequency transformer is between 30 and 6,000 cycles per second and for the higher grade types between 25 and 10,000 cycles per second.

**Ques. 6.11.** Why should the metallic case of a high-voltage transformer be grounded?

*Ans.* The metallic case of a high-voltage transformer is grounded to eliminate the building up of an electric field between the case and nearby objects. The grounding of the case also relieves the strain upon the high-voltage windings and the insulation. Grounding also serves as a physical protection against shocks between case and ground.

**Ques. 6.12.** What turns ratio should a transformer have which is to be used to match a source impedance of 500 ohms to a load of 10 ohms?

*Ans.* The correct turns ratio may be determined by the equation,

$$\text{Turns ratio} = \sqrt{\frac{Z_p}{Z_s}} = \sqrt{\frac{500}{10}} = 7.1, \text{ or } 7.1:1.$$

where  $Z_p$  = primary impedance.

$Z_s$  = secondary impedance.

**Ques. 6.13.** What would happen if a transformer, designed for operation on 500 cycles, were connected to a 60-cycle source of the same voltage?

*Ans.* The decrease in frequency would result in a heavy flow of current through the primary winding and may possibly cause it to burn out. This is due to the fact that the imped-

## RADIO OPERATING QUESTIONS AND ANSWERS

ance decreases as the frequency is lowered and would offer less opposition to the flow of alternating current.

**Ques. 6.14.** What would happen if a transformer, designed for operation on 60 cycles, were connected to a 120-cycle source of the same voltage?

*Ans.* The increase in frequency would lower the current flow through the primary winding due to the increase of the primary impedance. No damage would result, only a decrease in the output capabilities of the transformer.

**Ques. 6.15.** What is the principal disadvantage of using a dynamotor rather than a motor generator to furnish plate power to a small mobile transmitter?

*Ans.* The voltage output of a dynamotor is dependent upon the stability of the source voltage. Since the source voltage is generally of the battery variety the stability of the plate voltage may be affected with the change from full-load to light-load conditions. The variation in fully charged as compared with low-charged battery conditions will affect the generator output. The dynamotor, furthermore, does not possess the high degree of voltage output stability which the motor generator possesses.

**Ques. 6.16.** How may the voltage output of a dynamotor be regulated?

*Ans.* This may be accomplished by increasing or decreasing the source voltage.

**Ques. 6.17.** What is the line current of a single phase 7-horsepower alternating-current motor when operating from a 120-volt line at full-rated load and at a power factor of 0.8 and 95 per cent efficiency?

*Ans.* The line current under the above stated conditions will be 57.5 amperes. 1 horsepower = 746 electrical watts. 7 horsepower = 5,222 watts.

$$I = \frac{P}{E \times \text{p.f.} \times \text{Eff.}}$$

$$= \frac{5.222}{120 \times 0.80 \times 0.95} = 57.2 \text{ amperes.}$$

**Ques. 6.18.** What is the effect of an inductive load on the output voltage of an alternator?

*Ans.* An inductive load placed on the output terminals of an alternator will decrease its voltage and cause a lagging power factor.

**Ques. 6.19.** What is the principal advantage of the dynamotor, rather than the motor generator, to furnish plate power to a small mobile transmitter?

*Ans.* The principal advantage of the dynamotor over the motor generator is its compactness. In the dynamotor two separate armatures have their respective windings placed over a common iron core. The motor field and generator field are one unit which receives its excitation from the same source as the motor armature. It is a very compact and convenient unit for operation from a 6-volt storage battery to deliver plate supply voltages of 400 or more volts.

**Ques. 6.20.** Define "voltage regulation."

*Ans.* "Voltage regulation" is the change in voltage between full load and no load referred to the full-load value and expressed in per cent.

Voltage regulation in per cent may be determined by the following formula:

$$\text{Voltage regulation} = \frac{(\text{no-load voltage} - \text{full-load voltage})100}{\text{full-load voltage}}$$

**Ques. 6.21.** What means may be used to measure radio-frequency current?

*Ans.* Thermocouple ammeter, hot-wire ammeter.

**Ques. 6.22.** How may the range of a thermocouple ammeter be increased?

**Ans.** The range of a thermocouple ammeter may be increased by the insertion of a higher range thermocouple properly calibrated to fit the galvanometer for the higher range or by a low resistance (low-temperature-coefficient shunt) connected across the thermocouple current-carrying strip. The latter method is recommended only in cases of emergency. If the thermocouple is a separate unit, a multiplier resistor may be used in series with the meter.

**Ques. 6.23.** Does the scale of an alternating-current ammeter indicate peak or average current values? Explain your answer.

**Ans.** An alternating-current ammeter indicates neither peak nor average current values. The conventional alternating-current ammeter indicates effective current values.

The conventional alternating-current ammeter indicates effective current values. The average or peak values of a sinusoidal wave taken over a complete cycle is zero and consequently no deflection of these values can be obtained with ordinary alternating-current meters.

The theoretical reason for this condition may be more clearly understood by analyzing the action of the electro-dynamometer. This is an alternating-current or alternating-voltage indicating device which operates upon the principle illustrated in Fig. 6-1.

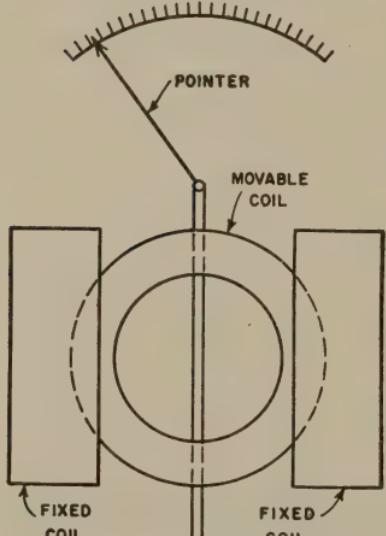


FIG. 6-1.—Dynamometer-type meter.

Two stationary coils are connected in series with a movable coil and a pointer. The electrical connection to the moving coil is made through two springs which also serve to resist the turning

force of the coil produced by the current. The force which tends to move the coil is proportional to the product of the field strength of the stationary and movable coils. Now since the field strength of each is proportional to the current which is flowing through them, the force tending to turn the coil at any instant is proportional to the square of the current flowing at that instant. Therefore, as this current varies from zero to the peak value for every half cycle, the force will also vary from zero to peak value each half of the cycle. The inertia of the coil, however, does not permit it to move rapidly enough to follow these fluctuations and, therefore, the pointer attached to the moving coil moves to a point corresponding to the average value of the deflecting force. Now since this is a measure of the current squared it will, therefore, be proportional to the effective value of the current.

**Ques. 6.24.** How may the power in an alternating-current circuit be determined?

**Ans.** The true power expended in an alternating-current circuit may be determined by a direct reading wattmeter or by the readings of an alternating-current voltmeter and an alternating-current ammeter multiplied by the power factor of the circuit. The power factor of a circuit is determined by the ratio of the resistance to the impedance of the circuit,

$$\text{Power factor} = \frac{R}{Z} \text{ or } \frac{W}{EI}.$$

$$\text{Power} = E \times I \times Pf \text{ watts.}$$

**Ques. 6.25.** A ship's transmitter has an antenna current of 8 amperes using A1 emission. What would be the antenna current when this transmitter is 100 per cent modulated by sinusoidal modulation?

**Ans.** When a continuous-wave transmitter is modulated by 100 per cent sinusoidal modulation the increase in antenna current will be 22.5 per cent. An increase of 22.5 per cent may be calculated by multiplying the unmodulated antenna current by 1.225, thus  $8 \times 1.225 = 9.8$  amperes.

**Ques. 6.26.** The direct-current plate input to a modulated class C amplifier, with an efficiency of 60 per cent, is 200 watts. What value of sinusoidal audio power is required in order to insure 100 per cent modulation? 50 per cent modulation?

*Ans.* For 100 per cent modulation, the modulator tube must supply audio-frequency power equal to 50 per cent of the unmodulated carrier plus 50 per cent of the power dissipated in the modulated-amplifier plate when unmodulated. Thus the audio-frequency power supplied by the modulator is,

$$P_{\text{mod}} = \frac{m^2 P_0}{2n}.$$

where  $m$  = modulation factor.

$n$  = estimated efficiency of the class C amplifier.

$P_0$  = unmodulated carrier power.

Since the input power in this example is 200 watts and the plate dissipation at 60 per cent efficiency is 80 watts the output power will be 120 watts. Thus the audio-frequency power required at 100 per cent modulation may be found by the equation,

$$\frac{1^2 \times 120}{2 \times n} = 100 \text{ watts.}$$

Now since the modulation factor for 100 per cent modulation is equal to 1 the modulation factor for 50 per cent modulation will be 0.5 (modulation factor  $\times$  100 = percentage of modulation). Thus, for 50 per cent modulation the audio-frequency power required will be

$$\frac{0.5^2 \times 120}{2 \times n} = \frac{0.25 \times 120}{1.2} = 25 \text{ watts.}$$

**Ques. 6.27.** What increase in antenna current will be observed when a radiotelephone transmitter is 100 per cent modulated by a sinusoidal wave form?

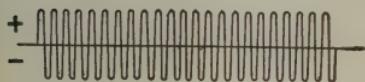
*Ans.* The antenna current when modulated 100 per cent will show an increase of 22.5 per cent over the unmodulated value assuming single-tone sinusoidal excitation.

**Ques. 6.28.** What is the total band width of a transmitter using A2 emission with a modulating frequency of 800 cycles and a carrier frequency of 500 kilocycles?

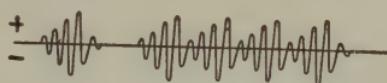
**Ans.** The band width of a 500 kilocycles radio frequency wave modulated at a modulating frequency of 800 cycles is 1,600 cycles or 1.6 kilocycles. The band width is computed on the basis of the upper and lower side-band frequencies,  $500,000 + 800$ ,  $500,000 - 800$ . The width of the band, therefore, is the difference between the upper and lower side bands.

**Ques. 6.29.** What are the general characteristics of the emission of a radiotelegraph transmitter which uses a chopper to obtain A2 emission?

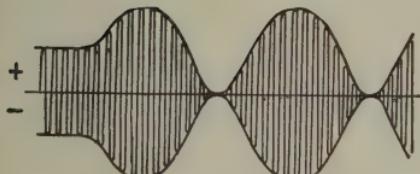
**Ans.** Figure 6-2 illustrates all types of emissions.



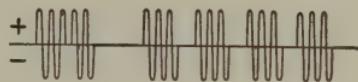
TYPE A0 AND A1



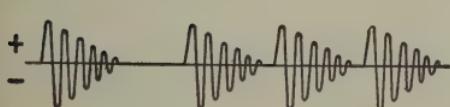
TYPE A2 (FULL WAVE)



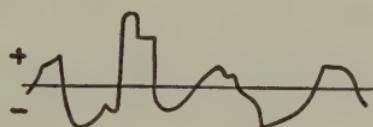
TYPE A3



TYPE A2 (CHOPPER)



TYPE B



TYPE A4 AND A5

FIG. 6-2.—Types of radio-wave emissions.

**Ques. 6.30.** How should the grid bias of a grid-modulated radio-frequency stage be adjusted?

*Ans.* The grid bias of a grid-modulated radio-frequency stage should be adjusted to a voltage value  $1\frac{1}{2}$  to 4 times the plate-current cut-off value.

**Ques. 6.31.** Compare the characteristics of plate and grid-bias modulation.

*Ans.* In the plate-voltage modulation (constant plate impedance) system the audio-frequency voltage is applied directly to the plate circuit of the radio-frequency stage to be modulated. In this system of modulation the source of signal voltage must supply a large part of the power supplied to the plate circuit. The operating efficiency is about 65 per cent.

In the grid-bias modulation (variable plate impedance) system the audio-frequency voltage, as well as the carrier voltage, is applied to the grid circuit. This system has the advantage over the plate modulation system in that it requires much lower exciting audio-frequency grid voltage, but gives a slight amount of increase in distortion. Efficiency is about 33 per cent.

Linear plate- and grid-modulation systems produce much less distortion compared with most systems at high modulation percentages. In addition, they are excellent for use in high-power transmission because of their high ratio of useful power output to the total power supplied to the plate circuit. The grid-bias adjustment in the modulated radio-frequency stage is  $1\frac{1}{2}$  to 4 times plate current cut-off in both systems.

**Ques. 6.32.** Is a high degree of modulation desirable in connection with a self-excited type of transmitter? Explain.

*Ans.* No. There are several very important reasons why a self-excited oscillator should not be modulated at a high degree of modulation. These are itemized as follows:

1. Frequency instability caused by power-supply load changes.

2. Frequency instability caused by changes in antenna constants, such as a swinging antenna, humidity changes, etc.
3. Rapid changes in frequency and amplitude, particularly with high percentages of modulation, will cause heavy changes in the output carrier frequency.
4. Poor quality of transmission.
5. Broader tuning response at the receiving station which may result in adjacent-station interference.

**Ques. 6.33. What is meant by "low-level modulation"?**

*Ans.* The term "low-level modulation" is applied to those types of radiotelephone transmitters in which the audio-frequency signal is applied to some one of the radio-frequency amplifier stages preceding the final power-amplifier stage.

**Ques. 6.34. Why is a series resistor used in the direct-current plate supply of a modulated radio-frequency amplifier, between the amplifier and the modulator, in a Heising modulation system?**

*Ans.* The dropping resistor is used in order that the radio-frequency amplifier will operate at a direct-current plate voltage lower than that of the modulator. This is necessary in order that the radio-frequency amplifier stage will be completely modulated. In other words, if the radio-frequency amplifier voltage is one-third less than that of the modulator, the radio-frequency amplifier will be completely modulated when the modulator develops a peak output voltage of two-thirds the direct-current plate potential.

**Ques. 6.35. Should the efficiency of a grid-bias modulated stage be maximum at complete modulation or zero modulation? Explain.**

*Ans.* The efficiency of a grid-bias modulated stage should be a maximum at complete modulation. This is so because the efficiency of plate-power conversion will be higher at complete modulation because some direct-current grid current

will be drawn at modulation peaks. It is, of course, important that the grid-current flow be not excessive, since that condition would introduce distortion. If the grid bias on a grid-modulated system is adjusted so that no grid current flows even on high peaks poor economy will result.

**Ques. 6.36. What is the purpose of a plate choke as used in Heising modulation?**

*Ans.* The primary purpose of the plate choke, or plate reactor, as it is commonly called, is to maintain a constant current in the modulator and modulated-amplifier plate circuits. The Heising system of modulation is often called the "constant current system" of modulation owing to the action of the plate reactor. The action of the choke may be more clearly understood from the following explanation: since the plate reactor is connected in the positive lead of the direct-current power supply and feeds simultaneously the voltage to the plates of both the modulator and the modulated-amplifier tubes any changes in the current flow in either plate circuit will be affected by the self-inductance of the coil. That is to say, when the grid of the modulator tube swings positive the plate current in this stage will increase. Owing to the large inductance of the reactor, however, the rise in current will change the polarity in accordance with the laws of induction. Thus the voltage developed across it by the expanding magnetic field will be 180 degrees out of phase with the direct-current voltage. This results in a decrease in the voltage on the plate of the modulated-amplifier tube owing to the bucking effect of the plate reactor upon the direct-current generator. When the grid of the modulator swings negative on the next half of the audio-frequency cycle the modulator plate current decreases. This causes the magnetic field around the plate reactor to contract thereby putting the reactor voltage in phase with the supply generator and increasing the voltage upon the plate of the modulated power-amplifier tube. This complete action varies the modulated-amplifier

voltage in accordance with the modulator changes and consequently varies the amplitude of the carrier frequency at an audio frequency.

**Ques. 6.37.** Does grid current flow in the conventional grid-bias modulated stage of a radiotelephone transmitter, under modulated conditions?

*Ans.* Yes. Grid current flows in slight amounts during the positive peaks of the audio-frequency excitation cycle. (See also Ques. 6.35.)

**Ques. 6.38.** If the first speech-amplifier tube of a radiotelephone transmitter were overexcited, but the percentage modulation capabilities of the transmitter were not exceeded, what would be the effect upon the output?

*Ans.* Overexcitation of the first tube in the speech input equipment would produce nonlinear distortion (amplitude distortion) in the plate circuit of the first tube which would be greatly amplified in each of the succeeding stages. Obviously this would badly distort the wave form of the modulated carrier and resulting transmission. The effect of amplitude distortion is generally referred to as *overloading* in the case of overexcitation.

**Ques. 6.39.** What types of microphones have a high impedance output?

*Ans.* Condenser and piezo-electric (crystal) types of microphones have a large output impedance. All microphones which operate upon the electrostatic principle are of the high-output impedance variety. Carbon microphones have a high-output impedance as compared with the low-impedance variety such as the dynamic or velocity types, but their impedance is low compared to the condenser and crystal types.

**Ques. 6.40.** What are the advantages of the single-button carbon microphone?

## RADIO OPERATING QUESTIONS AND ANSWERS

*Ans.* The main advantage of the single-button carbon microphone is that it does not require the careful adjustment of button balance since only a one-button current flows through the output transformer winding. In the double-button types the two currents in the respective halves must be carefully balanced for proper symmetry. Other advantages of the single button microphone are its relatively low cost, very high output, and low current consumption.

### **Ques. 6.41. Why is a speech amplifier used?**

*Ans.* Speech amplifiers are used to build up the voltages developed by the microphones to higher voltage amplitudes. High-audio-voltage amplitudes are required to transmit speech and musical frequencies to the modulating circuits, line circuits, and reproducers. Speech amplifiers are generally referred to as "voltage" or "gain" amplifiers. In any case where it is required to increase the audio-frequency voltage output of feeble generating (alternating-current) sources, a voltage or speech amplifier may be used.

### **Ques. 6.42. What might be the cause of a positive carrier shift during modulation?**

*Ans.* Carrier shift is that condition in a modulated wave in which the *average* value of the transmitted wave is changed in an upward or downward direction. Any situation which will change the average direct-current plate reading of the linear power-amplifier stage upward during modulation produces a positive carrier shift, and if downward, a negative carrier shift. In other words, any upset in the plate-circuit symmetry may cause a shift. Overmodulation *may* be the cause of either a positive or a negative carrier shift. Some other causes for a positive carrier shift are: excessive grid bias, poor bias-supply regulation, insufficient radio-frequency excitation. Negative carrier shift may be caused by: poor plate-supply regulation, insufficient grid bias or excessive radio-frequency excitation which causes grid current to flow.

**Ques 6.43.** What is the relation between the direct-current power input of the plate circuit of the stage being modulated, and the output audio power of the modulator for 100 per cent sinusoidal modulation?

*Ans.* For distortionless 100 per cent modulation capabilities the direct-current power input to the modulated radio-frequency amplifier stage should be twice the modulator's undistorted audio-frequency power output.

**Ques. 6.44.** In 100 per cent amplitude modulation, what is the ratio of peak antenna current to unmodulated antenna current?

*Ans.* The ratio of peak antenna current to unmodulated antenna current at 100 per cent modulation is 2:1, the peak modulated value rising to double the unmodulated value.

**Ques. 6.45.** In 100 per cent modulation, what is the ratio of instantaneous peak antenna power to unmodulated antenna power?

*Ans.* The peak power at 100 per cent modulation is four times the unmodulated power or, a ratio of 4:1

**Ques. 6.46.** Using a regenerative receiver, without radio-frequency amplifier stages, describe how you would adjust to receive radiotelegraph signals through interference.

*Ans.* To increase the selectivity of a regenerative receiver so as to reduce interference to a minimum, reduce the coupling between the primary and the secondary of the tuner and carefully retune the circuit to resonance by varying the secondary tuning condenser. Gradually increase the regeneration control to the point just before where self-oscillation is produced. Repeat the process critically by varying each of the tuning adjustments; namely, antenna series condenser, secondary tuning condenser, and the regeneration feedback control. Various degrees of loose coupling values should be chosen until

## RADIO OPERATING QUESTIONS AND ANSWERS

the proper degree of selectivity is obtained. It is important to remember however that each time the coupling is varied the circuit must be entirely retuned.

For continuous-wave reception the process is the same, with the exception that the regeneration control is increased to the point of self-oscillation so that an audible beat note may be produced.

**Ques. 6.47.** What is the effect upon the sound of received type B emission if the receiver detector is oscillating?

*Ans.* The tone frequency of the damped wave becomes badly distorted and it has a "mushy" tone characteristic.

**Ques. 6.48.** What effect does an incoming signal have upon the plate current of a triode detector of the grid-leak type?

*Ans.* The plate current will decrease. This is due to the fact that the grid-condenser blocking action causes a negative building up process or grid bias upon the grid with respect to the cathode. In other words, the grid leak develops an automatic grid bias during the periods in which the incoming signals prevail, thereby reducing the plate current.

**Ques. 6.49.** If broadcast signals interfered with your reception of signals on 500 kilocycles while aboard ship, how would you reduce or eliminate such interference?

*Ans.* The interference may be reduced or eliminated by the use of a tunable wave trap connected in the antenna circuit. The trap circuit is then tuned to the undesirable frequency. See Fig. 2-1.

**Ques. 6.50.** Describe how you could test a regenerative receiver to determine if the detector were in an oscillating condition?

*Ans.* One of the simplest tests to ascertain if the detector is in an oscillating condition is to touch the finger to the grid

of the tube. A loud "cluck" or "plop" should be heard in the telephones if the receiver is oscillating. Another simple test would be to bring the regeneration control up slowly from its minimum position towards maximum until a similar "plop" is heard. This will indicate that the circuit has gone into oscillation.

**Ques. 6.51.** Discuss the relative advantages and disadvantages of a stage of radio-frequency amplification as compared to a stage of audio-frequency amplification, for use in connection with a regenerative receiver.

*Ans.* The relative advantages of a stage of radio-frequency amplification in connection with a regenerative receiver are as follows:

1. Provides an increase in sensitivity.
2. Increases the circuit selectivity.
3. Eliminates reradiation from the oscillating detector into the antenna system.
4. Reduces the possibility of "dead spot" points when the oscillating detector is resonated with the antenna circuit.

The disadvantages of a stage of radio-frequency amplification before the oscillating detector are as follows:

1. A stage of radio-frequency amplification does not give so much audio-frequency volume as does one stage of audio-frequency amplification. This is particularly true if high step-up ratio audio-frequency transformers are used.
2. A radio-frequency stage requires careful shielding and filtering of all component parts to insure circuit stability. Design considerations are more exacting.
3. It generally requires an additional tuning stage.
4. It may require neutralization of inter-electrode grid-plate capacity to prevent amplifier self-oscillation.

**Ques. 6.52.** If a ship's regenerative receiver failed to oscillate when the regeneration control was advanced, explain the possible causes and remedies.

## RADIO OPERATING QUESTIONS AND ANSWERS

*Ans.* The following are the common causes for failure of a regenerative receiver to oscillate:

1. Low filament supply potential.
2. Deactivated filament. (Poor filament emission.)
3. Run-down plate-supply batteries.
4. Open plate by-pass condenser.
5. Open grid-coupling condenser.
6. Open grid leak.
7. High resistance contacts in some portion of the circuit.

The remedies in each case are obvious.

**Ques. 6.53.** Explain how you would test the various components of a receiver of the three-circuit regenerative type in trouble shooting.

*Ans.* Two basic tests are essential in trouble shooting a three-circuit regenerative receiver, namely;

1. Point-to-point continuity test with an ohmmeter or a pair of telephones with a battery in series, and
2. Voltmeter test.

The first step in servicing a receiver is to replace the old tubes with new ones to eliminate this common source of trouble. Then proceed as follows:

1. Test the voltages of the filament supply and plate supply across the filament terminals and plate to filament respectively with the voltmeter.
2. If the voltmeter indicates a reading when it is connected between the plate and the cathode at the socket terminals, it is evident that the entire plate circuit is continuous.
3. Test the circuit continuity with the ohmmeter or battery-telephone combination from the control grid to the cathode.
4. Test the continuity of the antenna coil by the same method.
5. Test all condensers for leaks or shorts.

**Ques. 6.54.** What is the effect of connecting a high value of resistance in parallel with the primary of an audio transformer in a regenerative receiver?

*Ans.* A high resistance connected across the primary winding of an audio-frequency transformer in a regenerative receiver prevents the annoying condition known as "fringe howl." The value of resistance should be in the order of 100,000 ohms.

**Ques. 6.55.** Why should a superheterodyne receiver, used for reception of A1 signals, be equipped with at least one stage of radio-frequency amplification ahead of the first detector?

*Ans.* A stage of radio-frequency amplification before the first detector serves as a pre-selector and reduces the possibility of image interference.

**Ques. 6.56.** What is the chief advantage to be gained in the utilization of high intermediate frequencies in a superheterodyne receiver?

*Ans.* The chief advantage to be gained in using high intermediate frequencies in a superheterodyne receiver is the reduction of image-frequency interference.

**Ques. 6.57.** If a superheterodyne receiver is receiving a signal on 1,000 kilocycles and the mixing oscillator is tuned to 1,500 kilocycles, what is the intermediate frequency?

*Ans.* The intermediate frequency is the difference between the incoming signal and the mixing oscillator frequency or, 500 kilocycles.

**Ques. 6.58.** Why is a diode detector employed in most modern radio receivers?

*Ans.* Diode detectors are used in most modern receivers because they more closely approach the ideal detecting or signal rectifying characteristics. In other words, a detection characteristic is obtained which resembles a straight line or linear character and, as a result, develops an audio signal of minimum distortion.

## *RADIO OPERATING QUESTIONS AND ANSWERS*

**Ques. 6.59.** What is the purpose of an auxiliary receiving antenna installed on a compulsorily equipped vessel, which is also fitted with a direction finder?

*Ans.* On a vessel required by law to maintain a watch by a qualified operator or operators, an effective auxiliary antenna or other approved arrangement shall be provided whenever deemed necessary by the Commission to avoid unauthorized interruption of this watch during use of a radio direction finder on board the same vessel.

**Ques. 6.60.** What is the primary purpose of the "break-in" relay associated with a radiotelegraph transmitter?

*Ans.* A break-in relay permits rapid interruption of the sequence of transmission by the receiving station in the event of interference or a break in the copying of the message. It permits listening periods during the actual transmission of messages. That is to say, when the transmitting key is open the relay contacts connect the antenna to the radio receiver and when the key is depressed it disconnects the antenna from the receiver and transfers it to the transmitter.

**Ques. 6.61.** When an antenna is erected, why should precautions be taken to prevent the wire from kinking?

*Ans.* The kinking of the wire weakens its physical structure at the point of the kink. Obviously, if the wire is subjected to strain and constant swaying, it may eventually break. Another possibility, particularly at very high radio frequencies, would be a loss of energy due to an increase in the high-frequency resistance because of sharp bends or kinks.

**Ques. 6.62.** What may be the causes of noisy operation of a regenerative, three-circuit receiver having two stages of audio-frequency amplification?

*Ans.* Tube noises caused by a high degree of amplification, excessive or critical regeneration adjustment, defective regen-

eration control (potentiometer type), defective grid leak, run down plate-supply or filament batteries, high-resistance contacts or poor grounding.

**Ques. 6.63.** How may the frequency of the antenna circuit of a shipboard receiver be lowered?

*Ans.* By decreasing the natural resonant frequency of the antenna circuit. This is accomplished by "loading" the antenna with a series inductance or loading coil.

**Ques. 6.64.** How may the frequency of the antenna circuit of a shipboard receiver be increased?

*Ans.* By decreasing the loading inductance value at the taps or by inserting an antenna series condenser.

**Ques 6.65.** What is the directional reception pattern of a loop antenna?

*Ans.* Figure 6-3 illustrates the directional pattern of a loop antenna.

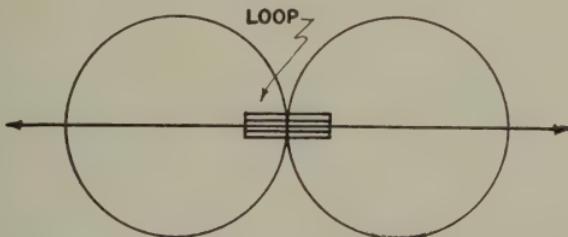


FIG. 6-3.—Directional pattern of a loop antenna.

**Ques. 6.66.** What is the directional reception pattern of a vertical antenna?

*Ans.* Figure 6-4 illustrates the directional pattern of a vertical antenna.

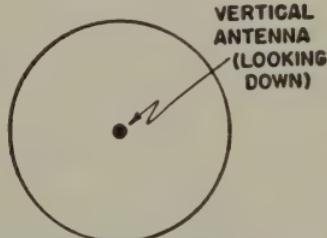


FIG. 6-4.—Directional pattern of a vertical antenna.

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 6.67. What is meant by "split tuning"?**

*Ans.* Split tuning refers to the double-peaked characteristic obtained with tight coupling. (See Ques. 5.195.)

**Ques. 6.68. Why should a transmitter be adjusted at reduced power?**

*Ans.* To protect the transmitter.

**Ques. 6.69. How is the power output of a vacuum-tube marine radiotelegraph transmitter usually adjusted?**

*Ans.* By varying the resistance of the generator-field rheostat, thereby increasing or decreasing the output plate voltage.

**Ques. 6.70. A marine transmitter uses 500 cycles alternating current for plate supply. It is rectified by a full-wave rectifier circuit, but is not filtered. How would the emission be classified?**

*Ans.* This type of emission is classified as, A2 (ICW). See Fig. 6-2.

**Ques. 6.71. In general, what advantages may be expected by the use of high frequencies in radio communication?**

*Ans.* Transmission over vastly greater distances with a relatively smaller amount of input power. Greater compactness of component parts.

**Ques. 6.72. How is the antenna aboard ship changed most rapidly from the transmitter to the receiver during the course of communication?**

*Ans.* By the use of a break-in relay system.

**Ques. 6.73. How can you determine the optimum coupling between the closed circuit of a spark transmitter and the antenna circuit?**

**Ans.** Optimum coupling may be determined by the antenna radio-frequency ammeter when the maximum deflection is obtained. The optimum coupling position for most spark transmitters should be somewhere in the vicinity of  $2\frac{1}{2}$  inches between the primary and secondary coils, depending upon the power used. A peak antenna current should be indicated at the resonant point which falls off rapidly as the coupling is either tightened or loosened from the optimum coupling point.

**Ques. 6.74.** What are the primary factors which determine the frequency emission of a spark transmitter?

**Ans.** The group or spark frequency of a spark transmitter is determined primarily by the speed of the alternator (power-transformer input frequency) and by the type of spark gap used. The radio-frequency emission is dependent upon the closed-circuit oscillatory constants of  $L$  and  $C$ .

**Ques. 6.75.** What is the best method of reducing the power output of a spark transmitter?

**Ans.** By reducing the generator output voltage. This is accomplished by increasing the resistance of the generator field rheostat. It is also necessary to reduce the spark gap.

**Ques. 6.76.** Why are protective condensers connected across the low potential alternating-current circuit of a spark transmitter?

**Ans.** To prevent possible damage to the alternator armature, motor armature, alternator field, motor field, primary of the power transformer and line equipment, which might be caused by high-frequency kick-back surges.

**Ques. 6.77.** Upon what factor(s) does the spark, or note frequency, of a spark transmitter depend?

**Ans.** The spark or note frequency depends primarily upon the alternating-current generator frequency and the gap interrupting frequency. The latter can vary the tonal fre-

quency when a rotary spark gap is used. The frequency of the generator is, however, the most important determinant and is dependent upon the speed of the alternating-current armature and the number of field poles and the time factor, thus

$$\text{Frequency} = \frac{N \times S}{2 \times 60} \text{ cycles per second,}$$

where  $N$  = the number of field poles,

$S$  = the speed in revolutions per minute

**Ques. 6.78. What factors determine the output frequency of a marine-arc type of radiotelegraph transmitter?**

*Ans.* The output frequency of a marine-arc transmitter is dependent upon the antenna capacity, antenna inductance, and the antenna series-loading inductance.

**Ques. 6.79. Why is it essential that pure water be used in the cooling system associated with an arc transmitter?**

*Ans.* Since the water passes through the positive electrode pure water must be used to prevent grounding or short-circuiting the high-voltage generator. Pure water has high dielectric or insulating properties and is, therefore, a poor conductor.

**Ques. 6.80. What is the purpose of the hydrogen gas, liberated from the injected alcohol, in the arc chamber?**

*Ans.* The purpose of burning an arc in an atmosphere of hydrogen is to increase the degree of ionization to assist in the reduction of the arc resistance. This increase in arc conduction manifests itself in the following:

1. Makes possible the generation of radio frequencies.
2. Increases the output radio-frequency energy.
3. Makes the arc burn steadier (produces a "fatter" arc).
4. Insures a more stable radiated frequency.
5. Makes for quicker ignition.

**Ques. 6.81.** Describe the back-shunt method of keying an arc transmitter.

**Ans.** Figure 6-5 illustrates the back-shunt system of arc keying. The back-shunt relay is actuated by a solenoid

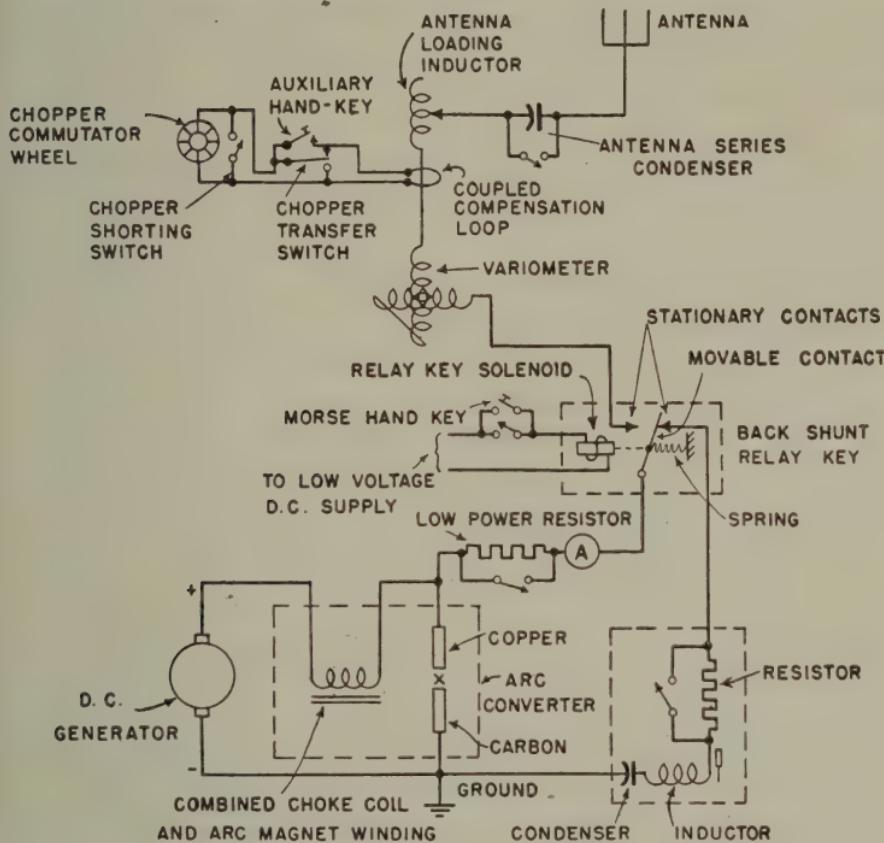


FIG. 6-5.—Arc back-shunt signaling system.

excited from the ship's direct current and controlled by a small Morse hand key in series with the solenoid. When the key is open, the back-shunt relay arm is connected to a closed absorption circuit into which the arc oscillates. When the key is closed, the arc is transferred to the antenna oscillatory system. This results in a uniwave signal emission, enables the operator to adjust the arc for maximum stability when the key is open, and eliminates unnecessary adjustment interference.

**Ques. 6.82.** Of what material is the anode of a marine arc transmitter composed?

*Ans.* Copper.

**Ques. 6.83.** Compare the advantages and disadvantages of a modern marine-type vacuum-tube transmitter and a marine spark transmitter.

*Ans.* The modern marine vacuum-tube transmitter has several very important advantages over the spark transmitter, namely:

1. Greater transmission coverage.
2. Creates less interference.
3. Lower frequency deviation (greater stability).
4. Requires less adjustment.
5. Lower power consumption (relatively).
6. Covers a greater frequency band.
7. Permits large variation of tonal frequency.
8. Permits simpler antenna design (physical).
9. Possesses greater flexibility.
10. Efficient on low and high powers.

The spark transmitter has an advantage only in that it does not require replacements, such as tubes. It transmits a relatively broader wave, which is desirable for distress transmissions only. It has less component parts to go out of order. It is useless for high frequency (short wave) transmission. It has very poor efficiency.

**Ques. 6.84.** What is meant by a "self-rectified" circuit, as employed in marine vacuum-tube telegraph transmitters?

*Ans.* Figure 6-6 illustrates a typical marine "self-rectifying" circuit. The plates of the tubes receive their voltage supply from the secondary winding of a high-voltage transformer. Since the plates are excited by an alternating voltage each tube is conductive only on alternate portions of the charging cycle, hence the name of self-rectification. If one

tube is used in the oscillatory circuit, and the alternating-current plate frequency from the power transformer is 500 cycles, the tone frequency of the radiated wave will be 500 cycles. If two tubes are used, full wave self-rectification will result and the tonal frequency will be 1,000 cycles.

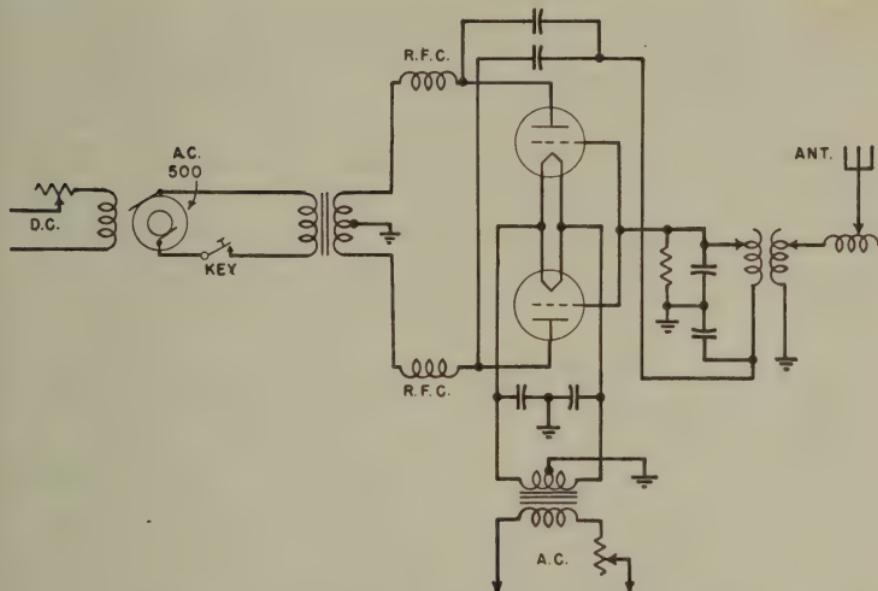


FIG. 6-6.—Marine self-rectifying transmitter circuit.

**Ques. 6.85.** What is the principal advantage to be gained by the use of a crystal-controlled oscillator in a marine radiotelegraph transmitter?

**Ans.** The crystal-controlled oscillator reduces frequency drifting to a minimum and, therefore, insures more stabilized transmission.

**Ques. 6.86.** Discuss the advantages and disadvantages of self-excited as compared to master-oscillator power-amplifier transmitters?

**Ans.** The self-excited oscillator has one important advantage over the master-oscillator power-amplifier system in that

## *RADIO OPERATING QUESTIONS AND ANSWERS*

it requires only one tube. Greater power output can be obtained with a minimum of tubes. Less component parts are required and, therefore, simpler tuning is obtained. One of the great disadvantages, however, is the inability of this type of oscillating system to maintain a steady carrier frequency. Frequency variations are produced by circuit load changes, particularly the antenna system. Changes in the antenna constants, caused by swinging, and varying humidity and temperature greatly affect the carrier frequency. Certain systems in which the self-excited oscillator is also modulated causes considerable frequency fluttering and distortion. Broad tuning and interference may result. All of these disadvantages are overcome by the master-oscillator power-amplifier system.

**Ques. 6.87. What is meant by the expression "motor generator is hunting"?**

*Ans.* "Hunting" is the term applied to motors and generators which swing or oscillate in their armatures when they are accelerated above and below their normal average speed. This swinging action is set up primarily by variations in the rotative speed resulting from irregularity in the turning force.

**Ques. 6.88. If the automatic starter for the transmitter motor generator failed to operate when the switch was closed, what might be the trouble?**

*Ans.* The starter or plunger solenoid may be open, the starting switch itself may be defective, the line-fuse blown, or the armature circuit may be open.

**Ques. 6.89. Why is a series motor not used in radio power-supply motors?**

*Ans.* The series motor does not maintain constant speed under a varying external load. If it were used to drive a generator, the output voltage and frequency would be unstable.

**Ques. 6.90.** If a 3-horsepower motor, operated from 110 volts, direct current, is 85 per cent efficient when developing its rated output, what will be the line current?

*Ans.* Three horsepower is equal to  $3 \times 746$  watts, or 2,238 watts. The current flow at 100 per cent efficiency will be,  $I = \frac{P}{E} = 20.34$  amperes. At 85 per cent efficiency, therefore, the line current will be 23.9 amperes.

**Ques. 6.91.** If an auxiliary storage battery has a voltage of 12.4 volts on open circuit, and 12.2 volts when the charging switch is closed, what is the difficulty?

*Ans.* This condition indicates that the charging polarity is reversed.

**Ques. 6.92.** Why should an Edison storage battery not be charged at less than the normal rate specified by the manufacturer? Explain.

*Ans.* Because the chemical reaction or oxidation process which takes place during the charge cannot be sufficiently accomplished at low charging rates. The internal resistance of the Edison cell is relatively higher than that of the lead-plate cell. Low capacity results from charging at less than the normal rate.

**Ques. 6.93.** Lacking an hydrometer, how may the state of charge of a storage battery be determined?

*Ans.* By the use of a high-resistance voltmeter under load conditions. It may also be determined by the gassing period while undergoing a charge, or by an ampere-hour meter.

**Ques. 6.94.** Your emergency storage battery has a specific gravity reading of 1.120. What should be done?

*Ans.* The battery should be filled with chemically pure water and immediately placed on full charge.

**Ques. 6.95.** Why should care be taken in the selection of water to be added to a storage cell to replace the loss by evaporation?

*Ans.* Chemically pure or distilled water should be used to deter chemical or metallic impurities from entering the solution. Impure water would generate local action and may ruin the cell.

**Ques. 6.96.** A discharged storage battery of three cells has an open-circuit voltage of 1.8 volts per cell and an internal resistance of 0.1 ohm per cell. What potential is necessary to produce an initial charging rate of 10 amperes?

*Ans.* The charging potential must be 8.4 volts.

*Solution:*

$$3 \times 1.8 \text{ v.} = 5.4 \text{ volts.}$$

$$3 \times 0.1 = 0.3 \text{ ohm (internal resistance).}$$

The voltage drop across the internal resistance when a current of 10 amperes will flow is,  $E = IR = 10 \times 0.3 = 3$  volts. Thus the charging voltage must be sufficient to overcome the  $IR$  drops, or  $5.4 + 3 = 8.4$  volts.

**Ques. 6.97.** What capacity of storage battery is required to operate a 50-watt emergency transmitter for 6 hours, assuming a continuous load of the transmitter of 70 per cent of the key-locked demand of 40 amperes? The emergency light load is 1.5 amperes.

*Ans.* A storage battery having a rated capacity of 200 ampere-hours would satisfy this condition. The actual capacity rating of the battery in accordance with the values given in this example, however, need be only 177 ampere-hours.

**Ques. 6.98.** Why does the charging rate to a storage cell, being charged from a fixed-voltage source, decrease as the charging progresses?

*Ans.* As the charging progresses the gravity of the electrolyte increases, the cell voltage increases and produces greater opposition to the charging current flow. Also, gas bubbles forming on the plates greatly increase the internal resistance, thereby reducing current flow.

**Ques. 6.99.** If you placed the emergency batteries on charge and the overload circuit breakers refused to stay closed, what is the trouble?

*Ans.* The charging voltage is reversed, no charging voltage is present, the charging voltage may be too low, or the charging circuit may be grounded.

**Ques. 6.100.** If part of the secondary winding of the power transformer of a transmitter were accidentally shorted, what would be the immediate effect?

*Ans.* The momentary rise in secondary current due to the short circuit would react upon the primary winding to decrease its self-inductance, thereby raising the primary current. A fuse would probably blow.

**Ques. 6.101.** What are the relative advantages of the condenser-input and choke-input filter circuits?

*Ans.* The condenser-input arrangement permits the use of lower rated high-voltage secondaries since the condenser serves to increase the voltage. The choke-input system introduces an additional voltage drop, but improves regulation. It also prevents flash back in systems where mercury-vapor rectifier tubes are used.

**Ques. 6.102.** What is the principal function of the filter in the power supply?

*Ans.* To smooth out the rectified ripples in order to provide a steady direct current to the vacuum-tube plates.

**Ques. 6.103.** How may a filter condenser be checked for leakage?

*Ans.* By the use of a voltmeter in series with a source of direct-current potential, or by an ohmmeter.

**Ques. 6.104.** What is the maximum allowable total secondary voltage of a transformer to be used as a center-tapped full-wave rectifier in connection with rectifier tubes having a peak inverse voltage rating of 10,000 volts?

*Ans.*  $E_{eff.} = E_{max.} \times 0.707 = 7,070$  volts.

**Ques. 6.105.** Discuss the uses of copper oxide rectifiers.

*Ans.* Copper oxide rectifiers are used most commonly in conjunction with direct-current voltmeters to read alternating-current voltages. Any direct-current galvanometer may serve a universal function for direct- and low-frequency alternating-current measurements by using it in conjunction with a copper oxide rectifier. They are used commercially as power rectifiers and peak limiters.

**Ques. 6.106.** Explain the principle of operation of the cold-cathode gaseous rectifying diodes.

*Ans.* These tubes operate solely upon the principle of the ionization of gases between two oppositely charged electrodes. For example, if a potential difference is applied between two electrodes enclosed in a glass bulb including an inert gas, such as neon or argon, the potential difference will cause the gas molecules to be broken up into positive units and negative units. The positive charges or ions move to the plate charged with the negative potential while the negative charges, or electrons, move toward the plate charged with the positive source potential.

**Ques. 6.107.** What are the advantages of the high-vacuum rectifier tube as compared to the hot-cathode gas-filled tube?

*Ans.* The advantages of the high-vacuum rectifier tube as compared to the hot-cathode gas-filled tube are the ability of the high-vacuum tube to withstand high inverse peak voltages

and to operate immediately without preheating. Comparing the efficiency of the high-vacuum-tube type with that of the mercury-vapor type, it has been found that the latter may be approximately 99 per cent efficient as compared with approximately 87 per cent for the former.

**Ques. 6.108.** What action permits the high-conduction currents of the hot-cathode gas-filled rectifier tube?

*Ans.* Ionization due to collision.

**Ques. 6.109.** What factors determine the setting of the sensitivity control of an auto-alarm receiver approved for installation on a vessel of the United States?

*Ans.* Optimum sensitivity and the prevention of receiver blocking by heavy static.

**Ques. 6.110.** If you were a radio operator on a vessel of the United States, equipped with an approved type of auto alarm which employs a linear detector and an electronic selector, what factors cause the bell to sound? The warning lights to operate?

*Ans.* The bells will be caused to ring by any of the following:

1. Receipt of an auto-alarm signal.
2. Receipt of a false-alarm signal caused by a combined static and keying interference (rare).
3. Failure of ship's line voltage or junction-box fuse.
4. Burned-out tube filament.
5. Failure of the 6-volt battery supply.

The warning lights may be caused to glow by any of the following:

1. Reception of signals where the key is depressed for a period considerably greater than 4.5 seconds.
2. Sensitivity control set too high for the prevailing noise level.

Warning lights may glow intermittently because of:

1. Occasional long bursts of static.

## RADIO OPERATING QUESTIONS AND ANSWERS

2. Keying interference due to dashes in excess of 3.5 seconds.
3. Heavy 500-kilocycle interference due to simultaneous transmission of several radiotelegraph transmitters.

**Ques. 6.111.** If you were a radio operator on a vessel of the United States, equipped with an approved type of auto alarm which employs a linear detector and an electronic selector, what would result upon failure of a vacuum-tube filament?

*Ans.* The bells would ring.

**Ques. 6.112.** With an auto alarm of the type which employs a linear detector and an electronic selector, what is the most probable cause of the intermittent ringing of the bells?

*Ans.* This would probably be caused by a fluctuating line voltage beyond certain limits.

**Ques. 6.113.** With an auto alarm of the type which employs a square-law detector and a mechanical selector, what factors cause the bell to sound? The warning lights to operate?

*Ans.* The bells will ring upon (1) receipt of true alarm signal, (2) receipt of false alarm signal, (3) failure of equipment in auto alarm, such as (a) failure of any heater, (b) storage-battery voltage too low, (c) selector fuse on battery charger blown or 24-volt circuit open, (d) motor stopped or running too slow, (e) heater circuit or 24-volt circuit to receiver open, or (f) ground on alarm-bell circuit.

The warning lights will operate upon the reception of a long dash, or because of strong local noise or static conditions. The remedy is to reduce the sensitivity control. The warning lights also operate when the ship's direct-current power fails or falls below 70 volts, thereby switching in the auxiliary B batteries.

**Ques. 6.114.** If an auto-alarm bell rings, and upon pressing the release button it does not stop, what could be the cause (s)?

*Ans.* Since the button is designed to break the bell circuit (in series) it is evident that the bells are electrically grounded or the relay arm is stuck in the closing position.

**Ques. 6.115.** If an auto-alarm bell rings, and upon pressing the release button it stops, what could be the cause(s) of the ringing?

*Ans.* Receipt of alarm signal, true or false. This condition may also be caused by the closing of the selector relay and is brought about by a break after a series of four dashes has been received.

**Ques. 6.116.** With an auto alarm of the type which employs a square-law detector and a mechanical selector, why does this receiver not respond to type A1 emission?

*Ans.* Type A1 emission is a continuous wave of constant amplitude; hence it cannot produce detector action when impressed on the grid of the square-law detector.

**Ques. 6.117.** From how many simultaneous directions is a direction finder capable of receiving signals if adjusted to take unilateral bearings through 360 degrees?

*Ans.* From all but one direction.

**Ques. 6.118.** What figure represents the reception pattern of a properly adjusted unilateral direction finder?

*Ans.* A cardioid figure as shown in Fig. 6-7, the heavy-line curve being the cardioid.

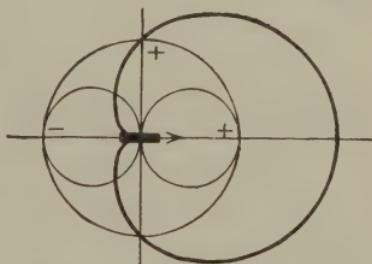


FIG. 6-7.—Unilateral characteristic.

**Ques. 6.119.** What is the principal function of a vertical antenna, associated with a unilateral direction finder?

*Ans.* To determine definitely the "sense" of direction.

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 6.120.** What is the principal function of the vertical antenna associated with the bilateral direction finder?

*Ans.* To provide proper balance and thereby minimize distortion of local field by near-by metal objects.

**Ques. 6.121.** Why are loop antennas, associated with direction finders, metallically shielded?

*Ans.* Metallic shielding minimizes the so-called "antenna effect." It permits the proper balancing of the loop by providing a symmetrical relation with respect to ground.

**Ques. 6.122.** What is a "compensator" as used with direction finders, and what is its purpose?

*Ans.* A "compensator" as used in direction finders is a device attached to the loop shaft which mechanically compensates the error on the compass indicator for the deviation caused by antenna effect owing to the presence of nearby metallic objects. This mechanical compensator automatically causes the compass indicator to lag or lead the plane of the direction-finder loop by the necessary amount to assure correct compensation.

**Ques. 6.123.** How is the unilateral effect obtained in a direction finder?

*Ans.* By the use of a small vertical antenna coupled to the loop direction finder. If the small antenna is so connected as to induce a small voltage in series with the loop, but 90 degrees out of phase with the voltage that the passing wave induces into the loop antenna, a unilateral sense of direction will be obtained.

**Ques. 6.124.** What factors may affect the accuracy of a properly compensated and calibrated direction finder, after installation?

*Ans.* Antenna effect. This is generally due to direct pick-ups from nearby metallic objects, but these may be

minimized by proper compensating adjustments. If all adjustments are properly made, the trouble is generally due to an erratic variation of the sky wave at night compared to ground waves. This is known as "night effect."

**Ques. 6.125.** What does the bearing obtained by the use of a bilateral radio direction finder indicate?

*Ans.* The line of direction along which the signal is traveling.

**Ques. 6.126.** What does the bearing obtained by the use of a unilateral direction finder indicate?

*Ans.* The sense of direction from which the signal emanates.

**Ques. 6.127.** If the vacuum-tube heater burns out, in an approved auto alarm, what causes the warning bells to ring?

*Ans.* The operation of a special relay in the receiver. This relay is in series with the heaters and controls the bell circuit.

**Ques. 6.128.** What is the function of the balancing condenser in a direction finder?

*Ans.* To provide the proper loop balance; that is, to balance out the stray capacity and inductive effects existing between the loop and ground. It permits the obtaining of a sharper null point.

**Ques. 6.129.** What signal will cause an approved auto-alarm receiver to ring the warning bell?

*Ans.*

1. Receipt of true-alarm signal.
2. Receipt of false-alarm signal.
3. Failure of equipment in auto alarm.

The following equipment troubles will cause the bell to sound:

1. Failure of any heater.
2. Storage-battery voltage too low.

3. Selector fuse on battery charger blown.
4. Motor stopped or running too low.
5. Vacuum-tube heater circuit or 24-volt circuit to receiver open.
6. Ground on alarm-bell circuit.

**Ques. 6.130.** To what frequency, or band of frequencies, is an approved auto-alarm receiver tuned?

*Ans.* A band of frequencies ranging from 487.5 to 512.5 kilocycles.

**Ques. 6.131.** What is the maximum permissible (root-mean-square) r.m.s. value of audio voltage which can be applied to the grid of a class A audio amplifier which has a grid bias of 10 volts?

*Ans.* Since the peak value must not exceed the 10 volts grid bias, the r.m.s. value of the audio signal must not exceed 7.07 volts.

$$E_{\text{r.m.s.}} = E_{\text{peak}} \times 0.707.$$

**Ques. 6.132.** What is the effect of leakage in the coupling condenser in an impedance or resistance-coupled amplifier?

*Ans.* Serious distortion will occur. This is so because the control grid of the succeeding tube will be positive with respect to cathode. A heavy rise in plate current and lowering in the plate voltage will occur, thereby seriously altering the plate  $I_p$ - $E_g$  curve.

**Ques. 6.133.** What is the direct-current plate voltage of a resistance-coupled amplifier stage which has a plate-supply voltage of 260 volts, a plate current of 1 milliampere, and a plate-load resistance of 100,000 ohms?

*Ans.* The potential difference between the plate and the cathode of the tube will be 160 volts.

$$E = IR = 100,000 \times 0.001 = 100 \text{ volts.}$$

$$260 - 100 = 160 \text{ volts}$$

**Ques. 6.134.** List four causes of distortion in a class A audio amplifier.

*Ans.* 1. Excessive grid excitation.  
2. Improper grid-bias adjustment.  
3. Improper plate-supply voltage adjustment.  
4. Improper value of load impedance.

**Ques. 6.135.** In a radio-frequency amplifier stage having a plate voltage of 1,250 volts, a plate current of 15 milliamperes, a grid current of 15 milliamperes, and a grid-leak resistance of 4,000 ohms, what is the value of the operating grid bias?

*Ans.*  $E = IR = 0.015 \times 4,000 = 60$  volts.

**Ques. 6.136.** In a radio-frequency amplifier, employing fixed grid bias, as the plate circuit is varied in adjustment from a point below resonance to a point above resonance, what effect will be observed on the grid current?

*Ans.* The grid current will normally rise slightly as the plate tank circuit is tuned through resonance.

**Ques. 6.137.** What is the primary function of the power-amplifier stage of a marine radiotelegraph transmitter?

*Ans.* To develop the power input for the antenna system and to provide the suitable coupling transfer. It also permits better frequency stability by isolating the oscillator from the antenna.

**Ques. 6.138.** In a series-fed plate circuit of a vacuum-tube amplifier, what could be the effect of a short circuit of the plate-supply by-pass condenser?

*Ans.* It would short-circuit the power supply.

**Ques. 6.139.** In a shunt-fed plate circuit of a vacuum-tube amplifier, what would be the effect of an open circuit in the plate radio-frequency choke?

## *RADIO OPERATING QUESTIONS AND ANSWERS*

*Ans.* The plate voltage would be removed from the tube plates.

**Ques. 6.140.** *What is the function of a dummy antenna?*

*Ans.* The dummy antenna is a noninductive resistance which serves as a substitute for the antenna resistance in making circuit adjustments without the use of an antenna. It enables the operator or engineer to make his power-amplifier output adjustments without creating unnecessary interference. In other words, it is a load substitution for an antenna.

**Ques. 6.141.** *What is the primary advantage to be obtained by shunting a high-resistance fixed resistor across each unit of a high-voltage series condenser bank in the power-supply filter circuit of a transmitter?*

*Ans.* To equalize the voltage drop across each condenser, distribute the strain, and to discharge the condensers after shutdown.

**Ques. 6.142.** *What is the effect of an inductance connected in series with the antenna circuit?*

*Ans.* It increases the fundamental wavelength of the antenna; that is, it decreases the antenna resonant frequency.

**Ques. 6.143.** *If a vacuum tube in the only radio-frequency stage in your receiver burned out, how could you make temporary repairs to permit operation of the receiver?*

*Ans.* The plate winding of the radio-frequency transformer may be used as the antenna primary coil. A coupling condenser from the antenna to the plate side of the radio-frequency tube socket may be used.

**Ques. 6.144.** *What is the meaning of "high-level" modulation?*

*Ans.* "High-level" modulation is that system in which the modulated-amplifier stage is also the final power-amplifier stage.

**Ques. 6.145.** What is the meaning of "low-level" modulation?

*Ans.* "Low-level" modulation is that system in which the modulated radio-frequency-amplifier stage precedes the final power-amplifier stage.

**Ques. 6.146.** If the plate current of the final radio-frequency amplifier in a transmitter increased and radiation decreased, although the antenna circuit is in good order, what would be the possible causes?

*Ans.* This may be due to a shorted turn in the secondary of the output-coupling transformer, a short-circuited secondary-shunt tuning condenser, or poor neutralization.

**Ques. 6.147.** A master-oscillator power-amplifier type of transmitter has been operating normally. Suddenly the antenna ammeter reads zero, although all filaments are burning and plate and grid meters are indicating normal voltages and currents. What would be the possible cause(s)?

*Ans.* This may be due to any of the following causes: Overloaded or defective ammeter, defective antenna insulation, circuits not in resonance, poor connections on the antenna, or improper coupling.

**Ques. 6.148.** What could cause abnormally low voltage at the input power terminals of a lifeboat radiotelegraph transmitter, while it is in operation?

*Ans.* This may be due to a low state of charge of the supply battery or excessive overloading.

**Ques. 6.149.** What is the result of excessive coupling between the antenna and output circuits of a self-excited type of vacuum-tube transmitter?

*Ans.* Erratic operation, tube overloading, and frequency instability. (See Ques. 5.195.)

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 6.150.** What is the purpose of the iron compound cylinders which are found in the inductances of certain marine radiotelegraph transmitters? The position of the cylinders, with respect to the inductances, is adjustable for what purpose?

*Ans.* These are provided for variable reactance tuning. They are adjustable so that the inductance value may be changed, thus affecting a change in frequency adjustment.

**Ques. 6.151.** What is the most common cause of split tuning?

*Ans.* Improper adjustment of mutual coupling.

**Ques. 6.152.** Should the antenna circuit of a master-oscillator, power-amplifier type of transmitter be adjusted to the resonant frequency before the plate-tank circuit of the final stage? Give the reason(s) for your answer.

*Ans.* No. The tank circuit should first be resonated to the excitation frequency for a minimum plate-current indication on the direct-current milliammeter. The antenna circuit is then tuned to resonance and the plate circuit readjusted to compensate for the antenna-loading effect. The minimum plate-current reading when the antenna is tuned to resonance with the plate-tank circuit will be higher than with untuned antenna conditions. Another reason for tuning the power amplifier first is that this stage must be neutralized before any antenna-transfer adjustments are made.

**Ques. 6.153.** In a transmitter involving a master oscillator, intermediate amplifier and final amplifier, describe the order in which circuits should be adjusted in placing this transmitter in operation.

*Ans.* From the master oscillator towards the antenna circuit.

**Ques. 6.154.** What is a "frequency-doubler" stage?

*Ans.* This is an amplifier in which the plate circuit is tuned to a harmonic of the grid-excitation frequency. It is generally adjusted to double that of the input frequency.

**Ques. 6.155.** Define "parasitic oscillations."

*Ans.* Spurious audio- or radio-frequency oscillations independent of the normal circuit frequency. They are commonly brought about by coupling between leads through parallel connecting of tubes.

**Ques. 6.156.** What is the effect of parasitic oscillations?

*Ans.* Erratic operation, circuit instability, possible serious overheating of the tubes, overloading, and decreased efficiency.

**Ques. 6.157.** What may cause a radio-frequency amplifier to have excessive plate current?

*Ans.* Improper neutralization, parasitic oscillation, excessive radio-frequency drive, insufficient load impedance, insufficient grid bias, excessive plate voltage, or improper output tuning.

**Ques. 6.158.** What are some of the indications of a defective vacuum tube in a transmitter?

*Ans.* Low plate-current readings if the trouble is due to low-filament emission, or excessive plate current if the tube has developed gas. Unstable readings during operation will result.

**Ques. 6.159.** At what point on a shipboard antenna system will the maximum potential be noted?

*Ans.* At the insulators, particularly at the one farthest away from the lead-in. This is generally referred to as the free or high-potential end.

**Ques. 6.160.** What is the effect upon a transmitter of dirty or salt-encrusted insulation?

## RADIO OPERATING QUESTIONS AND ANSWERS

*Ans.* Decreased radiation, erratic antenna, and plate milliammeter readings. Increased corona or brush discharge losses. Increased leakage losses.

**Ques. 6.161.** Why do many marine transmitters employ variometers rather than variable condensers as the tuning adjustments?

*Ans.* Because, in order to maintain a proper  $Q$  for various frequencies, the inductance rather than the capacity of the oscillatory circuit must be varied. The use of variometers also permits constant  $L-C$  ratio.

**Ques. 6.162.** What is the relationship between the antenna current and radiated power of an antenna?

*Ans.* The antenna current squared value  $\times$  the antenna resistance gives a true measure of radiated power.

**Ques. 6.163.** Why is a self-excited oscillator type of transmitter undesirable for shipboard service?

*Ans.* Because of its frequency instability.

**Ques. 6.164.** What is the fundamental difference(s) between the Hartley and Colpitts oscillators?

*Ans.* Both circuits obtain grid excitation directly from the resonant circuit, the Hartley from a portion of the tank coil, which is split for this purpose, and the Colpitts from a portion of the tank capacity through a split-condenser arrangement.

**Ques. 6.165.** How is the keying of a simple-oscillator type of emergency marine transmitter usually accomplished?

*Ans.* Transformer primary keying is generally used.

**Ques. 6.166.** If you found that it was impossible to keep the receiver-storage A battery charged, and at the same time maintain the required watch period, what remedy may be found?

*Ans.* The emergency power supply on board a cargo vessel (on which a separate main and emergency installation is not provided), subject to Title III, Part II of the Communications Act, while being navigated in the open sea, is authorized to be used only for emergency communication except that it may be used for routine communication for a period not to exceed one hour per day in the aggregate. However, a storage battery which is the emergency power supply or a part thereof, may be used at any time to maintain a watch for safety purposes if such use will not reduce the ability of the emergency power supply to energize the emergency installation for a period of at least six consecutive hours.

**Ques. 6.167.** What time zone shall be used in making log entries with respect to the observance of the international silent period?

*Ans.* The time of making an entry shall be shown opposite the entry and shall be expressed in Greenwich mean time (GMT) (counted from 00:00 to 24:00 o'clock, beginning at midnight). The first entry in each hour shall consist of four figures; additional entries in the same hour may be expressed in two figures by omitting the hour designation. The abbreviation "GMT" shall be marked at the head of the column in which the time is entered.

*Examples:*

Local Time	Greenwich Mean Time
12 midnight.....	0000
12:30 A.M.....	0030
6:00 A.M.....	0600
12:00 noon.....	1200
1:00 P.M.....	1300
4:00 P.M.....	1600
11:59 P.M.....	2359

**Ques. 6.168.** Under what circumstances must log entries be made regarding the observance of the international silent period?

## *RADIO OPERATING QUESTIONS AND ANSWERS*

*Ans.* During the period a watch is maintained by an operator, an entry shall be made twice per hour stating whether or not the international silent period was observed. In addition, entries shall be made indicating any signals or communications heard on 500 kilocycles (410 kilocycles on the Great Lakes) during this period. If no signals are heard on 500 kilocycles (410 kilocycles on the Great Lakes), an entry to that effect shall be made. The use of rubber stamps for making entries to show observation of the silent period is not authorized.

**Ques. 6.169. At what time(s) are routine transmissions forbidden in the bands of 480 to 520 kilocycles?**

*Ans.* In order to increase safety of life at sea (ships), and over the sea (aircraft), all the stations of the maritime mobile service which normally listen on the waves of the authorized bands between 365 and 515 kilocycles (822 and 583 meters) must, during their working hours, make the necessary provisions to insure the watch on the distress wave, 500 kilocycles (600 meters), twice per hour, for three minutes, beginning at x:15 and at x:45 o'clock, GMT.

**Ques. 6.170. At what time(s) must the international silent period be observed?**

*Ans.* (See Ques. 6.169).

**Ques. 6.171. After a distress call has been transmitted, every distress-traffic radiotelegram shall contain what symbol in the preamble?**

*Ans.* Every distress-traffic radiotelegram must include the distress signal preceding the call and repeated at the beginning of the preamble.

**Ques. 6.172. Under what conditions may a mobile station, the service of which is not continuous, close?**

*Ans.* Ship stations, the service of which is not continuous, may not close before having:

1. Finished all operations called for by a distress call.
2. Exchanged, as far as possible, all radiotelegrams originating in or destined to land stations which are within their range, and mobile stations which, being within their range, have signaled their presence before the effective cessation of work.

A mobile station which has no fixed working hours must advise the land station with which it is in communication of the closing and reopening hours of its service.

Any mobile station which arrives in a port and the service of which is accordingly about to close, must so advise the nearest land station and, if necessary, the other land stations with which it generally communicates. It must not close until it has cleared all traffic on hand, unless the regulations of the country where it calls prohibit. At the time of its departure, it must advise the interested land station or stations of its reopening, as soon as such reopening is permitted by the regulations in force within the country in which the port of departure is located.

**Ques. 6.173. How long must mobile stations listen after hearing an urgent signal?**

*Ans.* Mobile stations hearing the urgent signal must listen for at least 3 minutes. After this interval, and if no urgent message has been heard, they may resume their normal service.

**Ques. 6.174. What space of time should elapse between the transmission of the international auto-alarm signal and the distress call?**

*Ans.* When circumstances permit, the transmission of the distress call shall be separated from the end of the alarm signal by a two-minute silence.

**Ques. 6.175. What exceptions are permitted to the regulation which states that a mobile station, which has no fixed working hours, must advise the land station with which it is in communication of the closing and reopening hours?**

## *RADIO OPERATING QUESTIONS AND ANSWERS*

*Ans.* If the regulations of the country where the ship calls prohibit the use of the ship's radio transmitter while the ship is within the territorial waters of that country, the mobile station is not required by international law to report its closing to the nearest land station.

**Ques. 6.176.** How frequently must an entry be made in the marine radio log while a radio watch is being maintained?

*Ans.* Once every 15 minutes.

**Ques. 6.177.** During what periods must a distress message be repeated, following the initial transmission?

*Ans.* The distress message must be repeated at intervals until an answer has been received, and especially during the periods of silence.

**Ques. 6.178.** Upon what bodies of water is the frequency of 500 kilocycles not utilized as the international calling and distress frequency?

*Ans.* The frequency of 500 kilocycles is utilized as the international calling and distress frequency on all bodies of water.

**Ques. 6.179.** What station shall be in control of distress traffic?

*Ans.* The control of distress traffic shall devolve upon the mobile station in distress or upon the mobile station which has sent the distress call. These stations may delegate the control of the distress traffic to another station.

**Ques. 6.180.** What transmission should precede the transmission of the distress call?

*Ans.* The distress call, when sent in radiotelegraphy on 500 kilocycles (600 meters) shall, as a general rule, be immediately preceded by the alarm signal.

**Ques. 6.181.** Describe how a distress call should be made.

*Ans.* The distress call shall include:

1. The distress signal transmitted three times.
2. The word 'DE'.
3. The call signal of the mobile station in distress transmitted three times.

**Ques. 6.182.** Under what circumstances, and by whom, may the international auto-alarm signal be transmitted to announce an urgent cyclone warning?

*Ans.* The only purpose of this special signal is to set into operation the automatic apparatus used to give the alarm. It must only be used either to announce that a distress call or message is to follow, or to announce the transmission of an urgent cyclone warning; in the latter case it can only be used by coast stations duly authorized by their government.

**Ques. 6.183.** While a vessel is at sea, how frequently must the auto alarm be tested?

*Ans.* While the ship is being navigated outside a harbor or port, the auto alarm shall be tested at least once every 24 hours by means of the testing device supplied as part of the alarm, the timing of the dashes to be made by reference to the second hand of the ship-station clock. A statement that the foregoing requirement has been fulfilled must be inserted in the radio-station log daily.

**Ques. 6.184.** Describe the number of dashes, or dots, and spaces which compose the international auto-alarm signal and indicate the time intervals involved.

*Ans.* The alarm signal shall consist of a series of 12 dashes sent in one minute, the duration of each dash being four seconds and the duration of the interval between two dashes, one second. It can be transmitted by hand or by means of an automatic instrument. Any ship station working in the band

## RADIO OPERATING QUESTIONS AND ANSWERS

of 365 to 515 kilocycles (822 to 583 meters), and which is not provided with an automatic apparatus for the transmission of the auto alarm signal must be permanently equipped with a clock distinctly marking the seconds, preferably by means of a moving hand completing one revolution per minute. This clock must be placed at a point sufficiently visible from the keying table so that the operator may, by watching it, easily and correctly time the different elements of the alarm signal.

**Ques. 6.185. Describe the safety signal.**

*Ans.* In radiotelegraphy, the safety signal shall consist of the group TTT, transmitted three times, with the letters of each group, as well as the consecutive groups, well separated. This signal shall be followed by the word DE and three transmissions of the call signal of the station sending it. It announces that this station is about to transmit a message concerning the safety of navigation or giving important meteorological warnings.

In radiotelephony, the word SECURITY (corresponding to the French pronunciation of the word *sécurité*) repeated three times, shall be used as the safety signal.

**Ques. 6.186. During what periods must the safety signal be transmitted?**

*Ans.* In the maritime mobile service, apart from messages transmitted according to a schedule, the safety signal must be transmitted toward the end of the first ensuing period of silence, and the message shall be transmitted immediately after the period of silence.

**Ques. 6.187. Indicate the order of priority of the various types of radio communications.**

*Ans.* The order of priority of radio communications in the mobile service shall be as follows:

1. Distress calls, distress messages, and distress traffic.
2. Communications preceded by an urgent signal.

3. Communications preceded by a safety signal.
4. Communications relative to radio direction-finding bearings.
5. Government radiotelegrams for which priority right has not been waived.
6. All other communications.

**Ques. 6.188.** Upon hearing a safety signal, what should the operator at the receiving station do?

*Ans.* All stations hearing the safety signal must continue listening on the wave on which the safety signal has been sent until the message so announced has been completed; they must moreover keep silence on all waves likely to interfere with the message.

**Ques. 6.189.** When the auto-alarm bell rings, what should the operator do?

*Ans.* The alarm bell may be caused to ring for one or the other of the following reasons:

1. Receipt of true alarm signal from a distant station.
2. Failure of equipment in auto-alarm installation.

If the alarm rings, the operator must first determine if the bells are caused to ring by a failure in the auto-alarm equipment. He can do this by pressing the release button provided for this purpose. If the alarm bell *does not stop* when this button is pressed, there is trouble with the auto-alarm equipment. The operator must take the proper action to correct the trouble.

If the alarm bell *does stop* ringing when the release button is pressed, this signifies that a true alarm has been received. Under these conditions, the operator must go on watch immediately and listen in on the distress frequency for the distress call, distress message, or meteorological warning which should follow the alarm signal within two minutes. (See also Ques. 6.174 and 6.192.)

## RADIO OPERATING QUESTIONS AND ANSWERS

**Ques. 6.190.** If you received a distress call signed by a call signal composed of five letters, could you determine the type of craft which transmitted the signal?

*Ans.* The answer can be deduced from the following table:

1. Land stations have three-letter call signals.
2. Ship stations have four-letter call signals.
3. Aircraft stations have five-letter call signals.

**Ques. 6.191.** You intercept "CQ CQ WSV TFC QSY 735 AS." What does this mean?

*Ans.* CQ means general call "to all."

WSV is the call letter of a shore station.

TFC means "traffic."

QSY 735 means "shift to transmission on 735 meters."

AS means "wait" or "stand by for shift."

Hence, the above communication reads:

"All (ship) stations shift to 735 meters and listen to see if your call is included in the traffic list, signed WSV." (Consult Appendix I for further abbreviations.)

**Ques. 6.192.** Upon hearing an SOS, what should an operator do?

*Ans.* This call shall have absolute priority over other transmissions. All stations hearing it must immediately cease all transmission capable of interfering with the distress traffic, and must listen on the wave used for the distress call. This call must not be sent to any particular station and shall not require an acknowledgment of receipt.

**Ques. 6.193.** On a vessel of the United States equipped with an approved auto alarm where is the control button, which silences the warning bells, located?

*Ans.* Only one switch for stopping the audible warning apparatus from functioning is authorized and this shall be located in the main radiotelegraph operating room and shall be capable of manual operation only.

**Ques. 6.194. What is the radiotelegraph urgent signal?**

*Ans.* In radiotelegraphy, the urgent signal shall consist of the group XXX transmitted three times, with the letters of each group, as well as the consecutive groups, well separated; it shall be sent before the call.

**Ques. 6.195. With what type(s) of emission and upon what frequency should a transmitter be adjusted to transmit a distress call?**

*Ans.* In case of distress, the wave to be used shall be the international distress wave, that is, 500 kilocycles (600 meters); it must preferably be used with type A2 or B emission. Ship stations which cannot transmit on the international distress wave shall use their normal calling wave.

**Ques. 6.196. Upon what band of radio frequencies must an approved auto-alarm receiver function?**

*Ans.* From 487.5 to 512.5 kilocycles.

**Ques. 6.197. Upon compulsorily equipped vessels, which are required to have an accurate clock in the radio room, how frequently must this clock be adjusted and compared with standard time?**

*Ans.* At least once every 24 hours. For this purpose, authentic radio time signals received from land or fixed stations shall be acceptable as standard time.

**Ques. 6.198. Within what frequency-band limits do all United States marine radio-beacon stations operate?**

*Ans.* From 285 to 315 kilocycles.

**Ques 6.199. Upon what frequency should a navy direction-finding station be called to obtain a radio bearing?**

*Ans.* 375 kilocycles.

**Ques. 6.200. Upon what band, in addition to the 350-515 kilocycles band, must a main receiver on a compulsorily equipped United States ship be capable of operation? What is the purpose of this additional band?**

## RADIO OPERATING QUESTIONS AND ANSWERS

*Ans.* From 100 to 200 kilocycles. To provide long-wave radiotelegraph long-distance communication.

**Ques. 6.201.** While a vessel is in port, how frequently should the emergency equipment be tested?

*Ans.* Not at all, except just prior to departure.

**Ques. 6.202.** How frequently must the quantity of fuel in the supply tank for use with an oil or gas-driven emergency generator be checked, while the vessel is in the open sea?

*Ans.* Once each day.

**Ques. 6.203.** While the vessel is in the open sea, how frequently must the specific gravity of the emergency battery be taken?

*Ans.* Once each day.

**Ques. 6.204.** While the vessel is in the open sea, how frequently must the emergency equipment be tested?

*Ans.* Once each day.

**Ques. 6.205.** What is the principal port of the United States, on the Pacific Coast, at which navigation lines terminate?

*Ans.* San Francisco.

**Ques. 6.206.** In what city is the major telecommunication center of the United States located?

*Ans.* New York City.

**Ques. 6.207.** What is the approximate latitude of Colon, Republic of Panama?

*Ans.* This can be found in the table below.

Port	Latitude	Longitude
Colon, Panama.....	9.4°N	80°W
Los Angeles, Calif.....	34°N	118°W
New Orleans, La.....	30°N	90°W
New York, N. Y.....	41°N	74°W
San Francisco, Calif.....	38°N	122.5°W

**Ques. 6.208.** In what ocean is the island of Guam located?

*Ans.* Pacific Ocean.

**Ques. 6.209.** To what continent do the greatest number of telecommunication channels from the United States extend?

*Ans.* Europe.

**Ques. 6.210.** What is the principal Atlantic Coast port of the United States at which navigation lines terminate?

*Ans.* New York City.

**Ques. 6.211.** List four principles by which an e.m.f. may be generated by sound waves.

- Ans.* 1. Resistance variation (Carbon microphone).
- 2. Dynamic (Dynamic, or ribbon microphone).
- 3. Piezo-electric (Crystal microphone).
- 4. Electrostatic (Condenser microphone).

**Ques. 6.212.** What is indicated in a radiotelephone transmitter by an increase in antenna current without carrier shift?

*Ans.* Modulation must be taking place.

**Ques. 6.213.** What methods may be used to reduce fringe howl in a regenerative receiver?

*Ans.* Fringe howl may be eliminated by shunting a 100,000-ohm resistance across the primary winding of the detector audio-frequency transformer.

**Ques. 6.214.** Knowing the intermediate frequency and the signal to which a superheterodyne receiver is tuned, how would you determine the most probable frequency on which "image" reception would occur?

*Ans.* Any complement of frequencies other than the one to which the receiver is tuned which will give the value of the

intermediate frequency. In other words, the sum of the desired signal frequency and twice the value of the intermediate frequency is the "image" frequency.

**Ques. 6.215.** How is the degree of coupling varied in a *pi* network used to transfer energy from a vacuum-tube plate circuit to an antenna?

*Ans.* A *pi* network is shown in Fig. 4-11. The coupling is usually varied by adjusting the series inductance. To increase coupling decrease inductance, and vice versa.

**Ques. 6.216.** What means are usually provided to prevent operation of the ship's transmitter when the auto-alarm receiver is in use?

*Ans.* The transmitter key-relay power-supply circuit is opened when the auto-alarm receiver is in use.

**Ques. 6.217.** Explain how you would determine the value of the cathode-bias resistor for a specific-amplifier stage.

*Ans.* By referring to the tube characteristic chart for the proper operating voltages and currents, the bias resistor may be calculated by the formula,

$$R_{\text{bias}} = \frac{E_c}{I}$$

where  $I$  = the total return currents flowing to the cathode; namely, the plate and screen-grid currents.

**Ques. 6.218.** In a class A audio-frequency amplifier, what is the main advantage obtained through the use of two triodes in push-pull as compared to parallel operation?

*Ans.* Balancing out of the second harmonic component, hum, and subsequent distortion. Greater power output and prevention of core saturation in the transformer plate winding.

**Ques. 6.219.** Explain briefly the construction and characteristics of a beam power tube.

*Ans.* The basic structure of the beam tube is practically the same as for any pentode with the exception that an extra reflecting or beam-forming plate is placed near the plate so that the electrons are uniform in their progress towards the plate. This concentration of the electron stream towards the plate gives rise to a perfectly uniform distribution of the space charge. The control and screen grids are so aligned that the wires of the latter fall in the shadow of the former. Far greater power-output capabilities are achieved.

**Ques. 6.220.** Explain the operating procedure employed in neutralizing a radio-frequency power amplifier, using a thermocouple ammeter as an indicating device.

*Ans.* Open the plate-supply switch to the radio-frequency stage to be neutralized. Open up the main power switch to all tubes and discharge all high-voltage condensers. Insert a thermocoupled galvanometer into the low-potential side of the plate-tank circuit of the stage to be neutralized. Engage the neutralizing condenser about one-third position. Close the main power switch but leave the plate-supply switch of the amplifier open. Increase the radio-frequency drive gradually and tune all circuits to resonance. Observe the reading on the thermocouple galvanometer and vary the neutralizing condenser until this reading is a minimum or, preferably, zero. Remove the thermocouple galvanometer and insert the regular ammeter. Close the high-voltage plate-supply switch to the radio-frequency amplifier just neutralized. Carefully recheck and balance all circuits to minimum plate-current dips.

**Ques. 6.221.** For what purposes are decoupling networks used in audio-frequency amplifiers?

*Ans.* Decoupling networks are employed to stabilize amplifier operation. These networks reduce the common impedance coupling relations between circuits and thereby prevent regenerative effects and self-oscillation. Distortion is reduced and quality of reproduction is greatly improved.

**Ques. 6.222.** Under what circumstances is a station in the mobile service not required to listen to distress traffic?

*Ans.* A station of the mobile service which, while following distress traffic of which it is aware, is able to continue its normal service, may do so, when the distress traffic is well established, under the following conditions:

1. The use of the distress wave, 500 kilocycles (600 meters), of the wave on which the distress traffic is taking place and type-B waves shall be forbidden.
2. The use of type A1 waves, with the exception of those which might interfere with the distress traffic, shall be permitted.

**Ques. 6.223.** What interval of time must elapse between the end of the auto-alarm signal and an urgent cyclone warning?

*Ans.* Two minutes.

**Ques. 6.224.** Describe the international auto-alarm signal.

*Ans.* The alarm signal shall consist of a series of 12 dashes sent in one minute, the duration of each dash being four seconds and the duration of the interval between two dashes, one second. It can be transmitted by hand or by means of an automatic instrument. Any ship station working in the band of 365 to 515 kilocycles (822 to 583 meters), and which is not provided with an automatic apparatus for the transmission of the auto-alarm signal must be permanently equipped with a clock distinctly marking the seconds, preferably by means of a moving hand completing one revolution per minute. This clock must be placed at a point sufficiently visible from the keying table so that the operator may, by watching it, easily and correctly time the different elements of the alarm signal.

**Ques. 6.225.** What is the international distress frequency for stations in the mobile service?

*Ans.* 500 kilocycles.

## APPENDIX I\*

TABLE 1.—ABBREVIATIONS TO BE USED IN RADIO COMMUNICATIONS  
 Q CODE—ABBREVIATIONS TO BE USED IN ALL SERVICES<sup>1,2</sup>

Abbreviation	Question	Answer or statement
QRA	What is the name of your station?	The name of my station is . . .
QRB	At what approximate distance are you from my station?	The approximate distance between our stations is . . . nautical miles (or . . . kilometers).
QRC	By what private operating enterprise (or Government administration) are the accounts for charges of your station settled?	The accounts for charges of my station are settled by the . . . private operating enterprise (or by the Government administration of . . . ).
QRD	Where are you going and where do you come from?	I am going to . . . and I come from . . .
QRG	Will you tell me what my exact frequency (wavelength) is in kilocycles (or meters)?	Your exact frequency (wavelength) is . . . kilocycles (or . . . meters).
QRH	Does my frequency (wavelength) vary?	Your frequency (wavelength) varies.
QRI	Is the tone of my transmission regular?	The tone of your transmission varies.
QRJ	Are you receiving me badly? Are my signals weak?	I cannot receive you. Your signals are too weak.

<sup>1</sup> Abbreviations take the form of questions when they are followed by a question mark.

<sup>2</sup> The series of signals QA to QD and QF to QN are reserved for the special code of the aeronautical service.

\* Reprinted from the Government publication, "Study Guide and Reference Material for Commercial Radio Operator Examinations."

## RADIO OPERATING QUESTIONS AND ANSWERS

TABLE 1.—ABBREVIATIONS TO BE USED IN RADIO COMMUNICATIONS  
 Q CODE—ABBREVIATIONS TO BE USED IN ALL SERVICES<sup>1,2</sup>—(Continued)

Abbreviation	Question	Answer or statement
QRK	What is the legibility of my signals (1 to 5)?	The legibility of your signals is . . . (1 to 5).
QRL	Are you busy? . . .	I am busy (or I am busy with . . .). Please do not interfere.
QRM	Are you being interfered with?	I am being interfered with.
QRN	Are you troubled by static? . . .	I am troubled by static.
QRO	Must I increase the power? . . .	Increase the power.
QRP	Must I decrease the power? . . .	Decrease the power.
QRQ	Must I transmit faster? . . .	Transmit faster ( . . . words per minute).
QRS	Must I transmit more slowly?	Transmit more slowly ( . . . words per minute).
QRT	Must I stop transmission? . . .	Stop transmission.
QRU	Have you anything for me?	I have nothing for you.
QRV	Are you ready? . . .	I am ready.
QRW	Must I advise . . . that you are calling him on . . . kilocycles (or . . . meters)?	Please advise . . . that I am calling him on . . . kilocycles (or . . . meters).
QRX	Must I wait? When will you call me again?	Wait (or Wait until I have finished communicating with . . .). I shall call you again at . . . o'clock (or immediately).
QRY	Which is my turn? . . .	Your turn is number . . . (or according to any other indication).
QRZ	By whom am I being called?	You are being called by . . .
QSA	What is the strength of my signals (1 to 5)?	The strength of your signals is (1 to 5).

## APPENDIX I

**TABLE 1.—ABBREVIATIONS TO BE USED IN RADIO COMMUNICATIONS**  
**Q Code—ABBREVIATIONS TO BE USED IN ALL SERVICES<sup>1,2</sup>—(Continued)**

Abbreviation	Question	Answer or statement
QSB	Does the strength of my signals vary?	The strength of your signals varies.
QSD	Is my keying correct; are my signals distinct?	Your keying is incorrect; your signals are bad.
QSG	Must I transmit . . . telegrams ( <i>or</i> one telegram) at a time?	Transmit . . . telegrams ( <i>or</i> one telegram) at a time.
QSJ	What is the charge to be collected per word to . . . including your internal telegraph charge?	The charge to be collected per word to . . . is . . . francs, including my internal telegraph charge.
QSK	Must I continue the transmission of all my traffic; I can hear you between my signals?	Continue the transmission of all your traffic; I shall interrupt you if necessary.
QSL	Can you acknowledge receipt?	I am acknowledging receipt.
QSM	Must I repeat the last telegram which I transmitted to you?	Repeat the last telegram which you transmitted to me.
QSO	Can you communicate with . . . directly ( <i>or</i> through . . .)?	I can communicate with . . . directly ( <i>or</i> through . . .).
QSP	Will you relay to . . . free of charge?	I will relay to . . . free of charge.
QSR	Has the distress call received from . . . been attended to?	The distress call received from . . . has been attended to by . . .
QSU	Must I transmit ( <i>or</i> answer) on . . . kilocycles ( <i>or</i> meters) and/or on waves of type A1, A2, A3, or B?	Transmit ( <i>or</i> answer) on . . . kilocycles ( <i>or</i> . . . meters) and/or waves of type A1, A2, A3, or B.
QSV	Must I transmit a series of V's?	Transmit a series of V's.

## RADIO OPERATING QUESTIONS AND ANSWERS

**TABLE 1.—ABBREVIATIONS TO BE USED IN RADIO COMMUNICATIONS  
Q CODE—ABBREVIATIONS TO BE USED IN ALL SERVICES<sup>1,2</sup>—(Continued)**

Abbreviation	Question	Answer or statement
QSW	Do you wish to transmit on . . . kilocycles (or . . . meters), and/or on waves of type A1, A2, A3, or B?	I am going to transmit (or I shall transmit) on . . . kilocycles (or . . . meters), and/or on waves of type A1, A2, A3, or B.
QSX	Will you listen to . . . ( <i>call signal</i> ) on . . . kilocycles (or . . . meters)?	I am listening to . . . ( <i>call signal</i> ) on . . . kilocycles (or . . . meters).
QSY	Must I shift to transmission on . . . kilocycles (or . . . meters), without changing the type of wave? <i>or</i>	Shift to transmission on . . . kilocycles (or . . . meters) without changing the type of wave. <i>or</i>
QSZ	Must I shift to transmission on another wave?	Shift to transmission on another wave.
QTA	Must I transmit each word or group twice?	Transmit each word or group twice.
QTB	Must I cancel telegram no. . . as if it had not been transmitted?	Cancel telegram no. . . as if it had not been transmitted.
QTC	Do you agree with my word count?	I do not agree with your word count; I shall repeat the first letter of each word and the first figure of each number.
QTE <sup>3</sup>	How many telegrams have you to transmit?	I have . . . telegrams for you (or for . . . ).
	What is my true bearing in relation to you? <i>or</i>	Your true bearing in relation to me is . . . degrees <i>or</i>
	What is my true bearing in relation to . . . ( <i>call signal</i> )? <i>or</i>	Your true bearing in relation to . . . ( <i>call signal</i> ) is . . . degrees at . . . ( <i>time</i> ) <i>or</i>

<sup>3</sup> In certain aeronautical services, "true course" and "true bearing" are called "geographic course" and "geographic bearing."

## APPENDIX I

TABLE 1.—ABBREVIATIONS TO BE USED IN RADIO COMMUNICATIONS  
 Q CODE—ABBREVIATIONS TO BE USED IN ALL SERVICES<sup>1,2</sup>—(Continued)

Abbreviation	Question	Answer or statement
	What is the true bearing of . . . (call signal) in relation to . . . (call signal)?	The true bearing of . . . (call signal) in relation to . . . (call signal) is . . . degrees at . . . (time).
QTF	Will you give me the position of my station on the basis of bearings taken by the radio direction-finding stations which you control?	The position of your station on the basis of bearings taken by the radio direction-finding stations which I control is . . . latitude, . . . longitude.
QTG	Will you transmit your call signal during 50 seconds ending with a 10-second dash, on . . . kilocycles (or . . . meters) so that I may take your radio direction-finding bearings?	I will transmit my call signal during 50 seconds, ending with a 10-second dash, on . . . kilocycles (or . . . meters) so that you may take my radio direction-finding bearings.
QTH	What is your position in latitude and in longitude (or according to any other indication)?	My position is . . . latitude, . . . longitude (or according to any other indication).
QTI	What is your true course?..	My true course is . . . degrees.
QTJ	What is your speed?.....	My speed is . . . knots (or . . . kilometers) per hour.
QTM	Transmit radio signals and submarine sound signals to enable me to determine my bearing and my distance.	I am transmitting radio signals and submarine sound signals to enable you to determine your bearing and your distance.
QTO	Have you left dock (or port)?	I have left dock (or port).

## RADIO OPERATING QUESTIONS AND ANSWERS

TABLE 1.—ABBREVIATIONS TO BE USED IN RADIO COMMUNICATIONS  
 Q CODE—ABBREVIATIONS TO BE USED IN ALL SERVICES<sup>1,2</sup>—(Continued)

Abbreviation	Question	Answer or statement
QTP	Are you going to enter dock (or port)?	I am going to enter dock (or port).
QTQ	Can you communicate with my station by the International Code of Signals?	I am going to communicate with your station by the International Code of Signals.
QTR	What is the exact time? . . .	The exact time is . . .
QTU	What are the hours during which your station is open?	My station is open from . . . to . . .
QUA	Have you any news from . . . (call signal of the mobile station)?	This is the news from . . . (call signal of the mobile station).
QUB	Can you give me, in the following order, information concerning: visibility, height of clouds, ground wind at . . . (place of observation)?	This is the information requested: . . . . .
QUC	What is the last message you received from . . . (call signal of the mobile station)?	The last message I received from . . . (call signal of the mobile station) is . . .
QUD	Have you received the urgent signal transmitted by . . . (call signal of the mobile station)?	I have received the urgent signal transmitted by . . . (call signal of the mobile station) at . . . (time).
QUF	Have you received the distress signal sent by . . . (call signal of the mobile station)?	I have received the distress signal sent by . . . (call signal of the mobile station) at . . . (time).
QUG	Will you be forced to come down on water (or on land)?	I am forced to come down on water (or on land) at . . . (place).
QUH	Will you give me the present barometric pressure at sea level?	The present barometric pressure at sea level is . . . (units).

## APPENDIX I

TABLE 1.—ABBREVIATIONS TO BE USED IN RADIO COMMUNICATIONS  
 Q CODE—ABBREVIATIONS TO BE USED IN ALL SERVICES<sup>1,2</sup>—(Continued)

Abbreviation	Question	Answer or statement
QUJ <sup>3</sup>	Will you please indicate the proper course to steer toward you, with no wind?	The proper course to steer toward me, with no wind, is . . . degrees at . . . (time).
QUK	Can you tell me the condition of the sea observed at . . . (place or coordinates)?	The sea at . . . (place or coordinates) is . . .
QUL	Can you tell me the surge observed at . . . (place or coordinates)?	The surge at . . . (place or coordinates) is . . .
QUM	Is the distress traffic ended?	The distress traffic is ended.

<sup>3</sup> In certain aeronautical services, "true course" and "true bearing" are called "geographic course" and "geographic bearing."

TABLE 2.—SCALE FOR STRENGTH OR LEGIBILITY OF SIGNALS

Strength	Legibility
QSA 1 = scarcely perceptible	QRK 1 = unreadable
QSA 2 = weak	QRK 2 = readable now and then
QSA 3 = fairly good	QRK 3 = readable, but with difficulty
QSA 4 = good	QRK 4 = readable
QSA 5 = very good	QRK 5 = perfectly readable

QRR - Amateur "SOS" (Distress call)  
 Use only in serious emergency

## RADIO OPERATING QUESTIONS AND ANSWERS

TABLE 3.—MISCELLANEOUS ABBREVIATIONS

Abbreviation	Meaning
C	Yes.
N	No.
P	Announcing private telegram in the mobile service (to be used as a prefix).
W	Word or words.
AA	All after . . . (to be used after a question mark to request a repetition).
AB	All before . . . (to be used after a question mark to request a repetition).
AL	All that has just been transmitted (to be used after a question mark to request a repetition).
AS	Waiting period.
BN	All between . . . (to be used after a question mark to request a repetition).
BQ	Answer to RQ.
CL	I am closing my station.
CS	Call signal (to be used in requesting that call signal be given or repeated).
DB	I cannot give you a bearing, you are not in the calibrated sector of this station.
DC	The minimum of your signal is suitable for the bearing.
DF	Your bearing at . . . ( <i>time</i> ) was . . . degrees, in the doubtful sector of this station, with a possible error of two degrees.
DG	Please advise me if you find an error in the bearing given.
DI	Doubtful bearing due to the bad quality of your signal.
DJ	Doubtful bearing due to interference.
DL	Your bearing at . . . ( <i>time</i> ) was . . . degrees, in the uncertain sector of this station.
DO	Doubtful bearing. Request another bearing later, or at . . . ( <i>time</i> ).
DP	Beyond 50 miles, possible error of bearing can attain two degrees.
DS	Adjust your transmitter, your minimum signal is too broad.
DT	I cannot give you a bearing, your minimum signal is too broad.
DY	This is a two-way station, what is your approximate direction, in degrees, in relation to this station?
DZ	Your bearing is reciprocal (to be used only by the control station of a group of radio direction-finding stations when addressing other stations of the same group).

## APPENDIX I

**TABLE 3.—MISCELLANEOUS ABBREVIATIONS.—(Continued)**

Abbreviation	Meaning
ER	Here . . . (to be used before the name of the mobile station in the transmission of routing indications).
GA	Resume transmission (to be used more especially in the fixed service).
JM	If I may transmit, make a series of dashes. To stop my transmission, make a series of dots [not to be used on 500 kc. (600 m.)].
MN	Minute or minutes (to be used to indicate the duration of the waiting period).
NW	I am resuming transmission (to be used more especially in the fixed service).
OK	We agree.
RG	Announcing a request.
SA	Announcing the name of an aircraft station (to be used in transmitting transit data).
SF	Announcing the name of an aeronautical station.
SN	Announcing the name of a coast station.
SS	Announcing the name of a ship station (to be used in transmitting transit data).
TR	To announce sending of indications concerning a mobile station.
TU	Thank you for the cooperation given.
UA	Do we agree?
WA	Word after . . . (to be used after a question mark to request a repetition).
WB	Word before . . . (to be used after a question mark to request a repetition).
XS	Static.
YS	See your service notice.
ABV	Repeat (or I repeat) the figures in abbreviated form.
ADR	Address (to be used after a question mark to request a repetition).
CFM	Confirm (or I confirm).
COL	Collate (or I collate).
ITP	The punctuation counts.
MSG	Announcing a telegram concerning the service on board (to be used as a prefix).
NIL	I have nothing to transmit to you (to be used after an abbreviation of code Q to show that the answer to the question asked is in the negative).

*RADIO OPERATING QUESTIONS AND ANSWERS*

TABLE 3.—MISCELLANEOUS ABBREVIATIONS.—(Continued)

Abbreviation	Meaning
PBL	Preamble (to be used after a question mark to request a repetition).
REF	Reference to . . . (or Refer to . . . ).
RPT	Repeat (or I repeat) (to be used in requesting or giving repetition of all or part of the traffic, the abbreviation to be followed by the corresponding indications).
SIG	Signature (to be used after a question mark to request a repetition).
SVC	Announcing a service telegram concerning private traffic (to be used as a prefix).
TFC	Traffic.
TXT	Text (to be used after a question mark to request a repetition).

30 - Finish - End

73 - Best Regards

88 - Love & Kisses

## APPENDIX I

**TABLE 4.—INTERNATIONAL MORSE CODE**

*With extracts from the list of punctuations and other signs contained in the Telegraph Regulations of the Cairo Conferences, 1938*

LETTERS

a .—	i ..	r .—.
b —... .	j .—.—	s ...
c —.—.	k —.—.	t —
d —... .	l .—...	u .—.
e .	m ——	v .—.—
f .—.. .	n —.	w .—.—
g —.—.	o ——	x —... .
h ....	p .—.—.	y —.—.—
	q ——.—	z ——... .

FIGURES

1 .—.—.—	6 —... .
2 .—.—.—	7 —.—... .
3 .—.—.—	8 —.—.—.. .
4 .—.—.—	9 —.—.—.—.
5 ....	0 ——.—

PUNCTUATION AND OTHER SIGNS

Period.....	· .—.—.—
Comma.....	,
Colon.....	:
Question mark, or request for repetition of a transmission not understood.....	?
Apostrophe.....	,
Dash or hyphen.....	—
Fraction bar.....	/
Parenthesis (before and after words).....	( )
Underscore (before and after words or part of sentence).....	· .—.—.—
Equal sign.....	=
Understood.....	· · · — .
Error.....	· · · · .
Cross or end of telegram or end of transmission.....	· — . — .
Invitation to transmit.....	— . — .
Wait.....	· — . . .
End of work.....	· · · — .
Starting signal (beginning every transmission).....	· — . — .
Separation signal for transmission of fractional numbers (between the ordinary fraction and the whole number to be transmitted) and for groups consisting of figures and letters (between the figure groups and the letter groups).....	· — . — .

## RADIO OPERATING QUESTIONS AND ANSWERS

TABLE 4.—INTERNATIONAL MORSE CODE.—(*Continued*)

The following optional letters and signals may be used exceptionally on connections between countries allowing them:

å .—.—	ñ ——.——
á or å .—.—.—	ö ——.—.
ch ——.——	ü ..—.—
é ..—...	

In transmitting numbers involving a fraction, the separation signal must, in order to avoid confusion, be transmitted before or after the fraction, as the case may be.

*Examples.* Instead of  $1\frac{1}{16}$ , transmit 1 .—...  $\frac{1}{16}$  in order not to have it read  $1\frac{1}{16}$ ; instead of  $\frac{3}{4}8$ , transmit  $\frac{3}{4}$  .—... 8 in order not to have it read  $\frac{3}{4}8$ ; instead of  $2\frac{1}{2}2$ , transmit 2 .—...  $\frac{1}{2}$  .—... 2 in order not to have it read  $2\frac{1}{2}2$ .

A group consisting of figures and letters must be transmitted by inserting the separation signal (.—.—) between the figure group and the letter group.

## APPENDIX II\*

### PART 13.—RULES GOVERNING COMMERCIAL RADIO OPERATORS

#### GENERAL

**13.1. Licensed operators required.**<sup>1</sup>—Unless otherwise specified by the Commission, the actual operation of any radio station for which a station license is required shall be carried on only by a licensed radio operator of the required class.<sup>2</sup>

**13.2. Classes of licenses.**—The classes of commercial operator licenses issued by the Commission are:

*a.* Commercial radiotelephone group:

1. Radiotelephone second-class operator license.
2. Radiotelephone first-class operator license.

*b.* Commercial radiotelegraph group:

1. Radiotelegraph second-class operator license.
2. Radiotelegraph first-class operator license.

*c.* Restricted commercial group:

1. Restricted radiotelephone operator permit.
2. Restricted radiotelegraph operator permit.

**13.3. Dual holding of licenses.**—A person may not hold more than one radiotelegraph operator license (or restricted radiotelegraph permit) and one radiotelephone operator license (or restricted radiotelephone operator permit) at the same time.

**13.4. Term of licenses.**—Commercial operator licenses are normally issued for a term of 5 years from the date of issuance.

#### APPLICATIONS

**13.11. Procedure.**—The application form in duplicate for operator license, properly completed and signed, shall be submitted in person

\* Reprinted from the FCC publication, "Rules Governing Commercial Radio Operators."

<sup>1</sup> Wherever the term "license" is used generally to denote an authorization from the Commission, it includes both "license" and "permit."

<sup>2</sup> See Sec. 13.61.

or by mail to the office at which the applicant desires to be examined, which office will make the final arrangements for conducting the examination. If the application is for renewal of license,<sup>1</sup> it must be submitted during the last year of the license term and if the service requirements are fulfilled<sup>2</sup> the renewal license may be issued by mail. A renewal application shall also be accompanied by the license to be renewed.

**13.12.<sup>3</sup> Special provisions, radiotelegraph first class.**—An applicant for the radiotelegraph first-class operator license must be at least 21 years of age at the time the license is issued and shall have had an aggregate of 1 year of satisfactory service as a radiotelegraph operator manipulating the key of a manually operated radiotelegraph station on board a ship or in a manually operated coastal telegraph station.

### EXAMINATIONS

**13.21. Examination elements.**—Written examinations will comprise questions from one or more of the following examination elements:

1. *Basic law.*—Provisions of law and regulation with which every operator should be familiar.
2. *Basic theory and practice.*—Technical matters appropriate for every class of license except restricted radiotelephone operator permit.
3. *Radiotelephone.*—Additional matters, both legal and technical, including radiotelephone theory and practice.
4. *Advanced radiotelephone.*—Theory and practice applicable to broadcast station operation.
5. *Radiotelegraph.*—Additional matters, both legal and technical, including radiotelegraph theory and practice.
6. *Advanced radiotelegraph.*—Radiotelegraph theory and practice of wider scope, particularly with respect to ship radio matters (direction finders, ship radiotelephone stations, spark transmitters, etc.).

<sup>1</sup> All outstanding radiotelegraph licenses bearing an endorsement granting privileges comparable with a radiotelephone license of any class shall be considered as two separate licenses and application for renewal thereof shall be made separately.

<sup>2</sup> See Sec. 13.28.

<sup>3</sup> Radiotelegraph first-class licenses now held by persons under 21 years of age may be renewed without regard to the age limit provided by Sec. 13.12.

## APPENDIX II

**13.22. Examination requirements.**—Applicants for original licenses will be required to pass examinations as follows:

- a. Radiotelephone second-class operator license:
  1. Ability to transmit and receive spoken messages in English.
  2. Written examination elements: 1, 2, and 3.
- b. Radiotelephone first-class operator license:
  1. Ability to transmit and receive spoken messages in English.
  2. Written examination elements: 1, 2, 3, and 4.
- c. Radiotelegraph second-class operator license:
  1. Ability to transmit and receive spoken messages in English.
  2. Transmitting and receiving code test of sixteen (16) code groups per minute.
  3. Written examination elements: 1, 2, 5, and 6.
- d. Radiotelegraph first-class operator license:
  1. Ability to transmit and receive spoken messages in English.
  2. Transmitting and receiving code test of twenty-five (25) words per minute plain language and twenty (20) code groups per minute.
  3. Written examination elements: 1, 2, 5, and 6.
- e. Restricted radiotelephone operator permit:
  1. Ability to transmit and receive spoken messages in English.
  2. Written examination element: 1.
- f. Restricted radiotelegraph operator permit:
  1. Transmitting and receiving code test of sixteen (16) code groups per minute.
  2. Written examination elements: 1, 2, and 5.

**13.23. Form of writing.**—Written examinations shall be in English and shall be written by the applicant in longhand in ink, except that diagrams may be in pencil.

**13.24. Passing mark.**—A passing mark of 75 per cent of a possible 100 per cent will be required on each element of a written examination.

**13.25. New class, additional requirements.**—The holder of a license, who applies for another class of license, will be required to pass only the added examination elements for the new class of license.

**13.26. Canceling and issuing new licenses.**—If the holder of a license qualifies for a higher class in the same group, the license held will be canceled upon the issuance of the new license. Similarly, if the holder of a restricted operator permit qualifies for a first- or

## *RADIO OPERATING QUESTIONS AND ANSWERS*

second-class operator license of the corresponding type, the permit held will be canceled upon issuance of the new license.

**13.27. Eligibility for reexamination.**—An applicant who fails an examination element will be ineligible for 2 months<sup>1</sup> to take an examination for any class of license requiring that element. Examination elements will be graded in the order listed,<sup>2</sup> and an applicant may, without further application, be issued the class of license for which he qualifies.

**13.28. Renewal examinations and exceptions.**<sup>3</sup>—A license may be renewed without examination provided the service record on the license<sup>4</sup> shows at least 3 years' satisfactory service in the aggregate during the license term and while actually employed as a radio operator under that license; or shows at least 2 years' service in the aggregate, under the same conditions, of which 1 year must have been continuous and immediately prior to the date of application for renewal.

If the above requirements have not been fulfilled, but the service record shows at least 3 months' satisfactory service in the aggregate, while actually employed as a radio operator under the license during the last 3 years of the license term, a license may be renewed upon the successful completion of a renewal examination which may be taken at any time during the last year of the license term.

<sup>1</sup> A month after date is the same day of the following month, or if there is no such day, the last day of such month. This principle applies for other periods. For example, in the case of the 2-month period to which this note refers, an applicant examined December 1 may be reexamined February 1, and an applicant examined December 29, 30, or 31 may be reexamined the last day of February, while one examined February 28 may be reexamined April 28.

<sup>2</sup> See Sec. 13.28.

<sup>3</sup> Paragraph (2) of rule 439 shall remain in effect with respect to renewals of 3-year licenses outstanding on July 1, 1939.

“RULE 439 (2) All operator licenses, except amateur, may be renewed without examination, provided—

“(a) The applicant has had 90 days' satisfactory service during the 6-month period prior to the date the application for renewal of license is due to be filed, namely, 60 days prior to the expiration date, or

“(b) The applicant has had at least 12 months' satisfactory service during the license term prior to the date the application for renewal of license is due to be filed.”

<sup>4</sup> See Secs. 13.91 to 13.94, inclusive.

Renewal examinations will consist of the same elements as for original licenses. However, the written examination will be directed toward a determination of the applicant's qualifications to continue to hold the license for which he has previously qualified. If the renewal examination is not successfully completed before expiration of the license sought to be renewed, or if the service is not acceptable, the applicant will be examined as for the original license.

### CODE TESTS

**13.41. Transmitting speed requirements.**—An applicant is required to transmit correctly in the International Morse Code for 1 minute at the rate of speed prescribed in these rules for the class of license desired.

**13.42. Transmitting test procedure.**—Transmitting tests shall be performed by the use of the conventional Morse key except that a semi-automatic key, if furnished by the applicant, may be used in transmitting code tests of 25 words per minute.

**13.43. Receiving speed requirements.**—An applicant is required to receive the International Morse Code by ear, and legibly transcribe consecutive words or code groups for a period of 1 minute without error at the rate of speed specified in the rules for the class of license for which application is made.

**13.44. Receiving test procedure.**—Receiving code tests shall be written in longhand either in ink or pencil except that in the case of the 25 words per minute code test, a typewriter may be used when furnished by the applicant.

**13.45. Computing word or code groups.**—Each five characters shall be counted as one word or code group. Punctuation marks or figures count as two characters.

### SCOPE OF AUTHORITY

**13.61. Operators' authority.**—The various classes of commercial operator licenses issued by the Commission authorize the holders thereof to operate radio stations, except amateur, as follows:

*a. Radiotelephone second-class operator license.*—Any station while using type A-0, A-3, A-4, or A-5 emission except standard broadcast stations, International Broadcast stations, or ship stations licensed to use power in excess of 100 watts and type A-3 emission for communication with coastal telephone stations.

## RADIO OPERATING QUESTIONS AND ANSWERS

*b. Radiotelephone first-class operator license.*—Any station while using type A-0, A-3, A-4, or A-5 emission except ship stations licensed to use a power in excess of 100 watts and type A-3 emission for communication with coastal telephone stations.

*c. Radiotelegraph second-class operator license.*—Any station while using type B, A-0, A-1, A-2, A-3, or A-4 emission except—

1. Any of the various classes of broadcast stations other than a relay broadcast station, or
2. On a passenger<sup>1</sup> vessel required by treaty or statute to maintain a continuous radio watch by operators or on a vessel having continuous hours of service for public correspondence, the holder of this class of license may not act as chief operator.
3. On a vessel (other than a vessel operated exclusively on the Great Lakes) required by treaty or statute to be *equipped* with a *radiotelegraph* installation, the holder of this class license may not act as chief or sole operator until he has had at least 6 months' satisfactory service as a qualified radiotelegraph operator on a vessel of the United States.

*d. Radiotelegraph first-class operator license.*—Any station while using type B, A-0, A-1, A-2, A-3, or A-4 emission except—

1. Any of the various classes of broadcast stations other than a relay broadcast station.
2. On a *cargo vessel* (other than a vessel operated exclusively on the Great Lakes) required by treaty or statute to be *equipped* with a *radiotelegraph* installation, the holder of this class license may not act as chief or sole operator until he has had at least 6 months' satisfactory service as a qualified radiotelegraph operator on a vessel of the United States.

*e. Restricted radiotelephone operator permit.*—Any station while using type A-0, A-3, or A-4 emission: *Provided, That*—

1. Such operator is prohibited from making adjustments that may result in improper transmitter operation.
2. The equipment is so designed that none of the operations necessary to be performed during the course of normal

<sup>1</sup> A ship shall be considered a passenger ship if it carries or is licensed or certificated to carry more than 12 passengers. A cargo ship means any ship not a passenger ship.

## APPENDIX II

rendition of service may cause off-frequency operation or result in any unauthorized radiation.

3. Any needed adjustments of the transmitter that may affect the proper operation of the station are regularly made by or in the presence of an operator holding a first or second class license, either telephone or telegraph, who shall be responsible for the proper operation of the equipment.

Exceptions:

1. The permit is not valid for the operation of any of the various classes of broadcast stations other than a relay broadcast station.
2. The permit is not valid for the operation of a coastal telephone station or a coastal harbor station other than in the Territory of Alaska.
3. The permit is not valid for the operation of a ship station licensed to use type A-3 emission for communication with coastal telephone stations.

*f. Restricted radiotelegraph operator permit.*—Any station while using type B, A-0, A-1, A-2, A-3, or A-4 emission: *Provided*, That, in the case of equipment designed for and using type A-3 or A-4 emission—

1. Such operator is prohibited from making adjustments that may result in improper transmitter operation.
2. The equipment is so designed that none of the operations necessary to be performed during the course of normal rendition of service may cause off-frequency operation or result in any unauthorized radiation.
3. Any needed adjustments of the transmitter which may affect proper operation of the station are regularly made by or in the presence of an operator holding a first or second class license, either telephone or telegraph, who shall be responsible for the proper operation of the equipment.

Exceptions:

1. The permit is not valid for the operation of any of the various classes of broadcast stations other than a relay broadcast station.
2. The permit is not valid for the operation of a ship station licensed to use type A-3 emission for communication with coastal telephone stations.

## RADIO OPERATING QUESTIONS AND ANSWERS

3. The license is not valid for the operation of a radiotelegraph station on board a vessel required by treaty or statute to be equipped with a radio installation.
4. The license is not valid for the operation of any ship telegraph, coastal telegraph, or marine-relay station open to public correspondence.

**13.62. Special privileges.**—(a) Any operator may operate any station in the experimental service, while using frequencies above 300,000 kilocycles.

b. Subject to the limitations set forth herein,<sup>1</sup> the holder of any class radiotelephone operator license may operate a radiotelephone point-to-point station, a coastal harbor, or coastal telephone station while using A-1 or A-2 emission, for testing or other transmission entirely secondary and incidental to the service of such station.

**13.63. Operator's responsibility.**—The licensed operator responsible for the maintenance of a transmitter may permit other persons to adjust a transmitter in his presence for the purpose of carrying out tests or making adjustments requiring specialized knowledge or skill, provided that he shall not be relieved thereby from responsibility for the proper operation of the equipment.

## MISCELLANEOUS

**13.71. Issue of duplicate license.**—An operator whose license or permit has been lost, mutilated, or destroyed, shall immediately notify the Commission. A sworn application for duplicate should be submitted to the office of issue embodying a statement attesting to the facts thereof. If a license has been lost, the applicant must state that reasonable search has been made for it, and further, that in the event it be found either the original or the duplicate will be returned for cancellation. The applicant must also give a statement of the service that has been obtained under the lost license.

**13.72. Exhibiting signed copy of application.**—When a duplicate operator license or permit has been requested, or request for renewal upon service has been made, the operator shall exhibit in lieu thereof a signed copy of the application for duplicate, or renewal, which has been submitted by him.

**13.73. Supervision of examinations for permit.**—Persons other than employees of the Commission may be authorized to supervise

<sup>1</sup> Section 13.61.

## APPENDIX II

examinations for Restricted Radiotelephone Operator Permits for one or more employees of a division of local or State Government: *Provided*—

a. That the absence of such employees for the purpose of taking an examination at a field office or designated examining city would interfere with the proper functioning of the division, and

b. That the chief of police, director of public safety, or other official of equal responsibility furnish the names of the persons to be examined and designate an official by name and title to supervise the examination. The application for supervisory examination shall be made to the inspector in charge of the district in which the applicants are located.

**13.74. Verification card.**—The holder of an operator license who operates any station in which the posting of an operator license is not required, may, upon filing application<sup>1</sup> in duplicate, accompanied by his license, obtain a Verification Card.<sup>2</sup> This card may be carried on the person of the operator in lieu of the original operator license: *Provided*, The license is readily accessible within a reasonable time for inspection upon demand by an authorized Government representative.

**13.75. Posting license or verified statement.**—The holder of a radiotelegraph or radiotelephone first or second class license who is employed as a service and maintenance operator at stations operated by holders of Restricted Operator Permits shall post at such station his operator license or a verified statement from the Commission<sup>3</sup> in lieu thereof.

### SERVICE

**13.91. Endorsement of service record.**—A station licensee, or his duly authorized agent, or the master of a vessel acting as the agent of a licensee, shall endorse the service record appearing on said operator license, showing the call letters and types of emission of the station operated, the nature and period of employment, and quality of performance of duty.

**13.92. Aviation service endorsement.**—If the operator has operated more than three stations in the aviation service, the service may be shown by giving the name of the aviation chain or company in lieu of listing the call letters of the several stations.

<sup>1</sup> Form 756.

<sup>2</sup> Form 758-F.

<sup>3</sup> Form 759.

## *RADIO OPERATING QUESTIONS AND ANSWERS*

**13.93. Service acceptability.**—Credit will be allowed only for satisfactory service obtained under conditions that required the employment of licensed operators, or when obtained at United States Government stations.

**13.94. Statement in lieu of service endorsement.**—The holder of a radiotelegraph license or a restricted radiotelegraph operator permit desiring an endorsement to be placed thereon attesting to an aggregate of at least 6 months' satisfactory service as a qualified operator on a vessel of the United States, may, in the event documentary evidence cannot be produced, submit to any office of the Commission a statement under oath accompanied by the license to be endorsed, embodying the following:

- a.* Names of ships at which employed
- b.* Call letters of stations.
- c.* Types of emission used.
- d.* Type of service performed as follows.
  1. Manual radiotelegraph operation only; and
  2. Transmitter control only; or
  3. Combination of (1) and (2) running concurrently.
- e.* Whether service was satisfactory or unsatisfactory.
- f.* Period of employment.
- g.* Name of master, employer, licensee, or his duly authorized agent.

## APPENDIX III

### EXTRACTS FROM RADIO LAWS

Extracts of the Communications Act of 1934, as amended

**SECTION 1.** For the purpose of regulating interstate and foreign commerce in communication by wire and radio so as to make available, so far as possible, to all the people of the United States a rapid, efficient, Nation-wide, and world-wide wire and radio communication service with adequate facilities at reasonable charges, for the purpose of the national defense, for the purpose of promoting safety of life and property through the use of wire and radio communication, and for the purpose of securing a more effective execution of this policy by centralizing authority heretofore granted by law to several agencies and by granting additional authority with respect to interstate and foreign commerce in wire and radio communication, there is hereby created a Commission to be known as the "Federal Communications Commission," which shall be constituted as hereinafter provided, and which shall execute and enforce the provisions of this act.

**Sec. 301.** It is the purpose of this Act, among other things, to maintain the control of the United States over all the channels of interstate and foreign radio transmission; and to provide for the use of such channels, but not the ownership thereof, by persons for limited periods of time, under licenses granted by Federal authority, and no such license shall be construed to create any right, beyond the terms, conditions, and periods of the license. No person shall use or operate any apparatus for the transmission of energy or communications or signals by radio (a) from one place in any Territory or possession of the United States or in the District of Columbia to another place in the same Territory, possession, or district; or (b) from any State, Territory, or possession of the United States, or from the District of Columbia to any other State, Territory, or possession of the United States; or (c) from any place in any State, Territory, or possession of the United States, or in the District of Columbia, to any place in any foreign country or to any vessel; or (d) within any State when

## *RADIO OPERATING QUESTIONS AND ANSWERS*

the effects of such use extend beyond the borders of said State, or when interference is caused by such use or operation with the transmission of such energy, communications, or signals from within said State to any place beyond its borders, or from any place beyond its borders to any place within said State, or with the transmission or reception of such energy, communications, or signals from and/or to places beyond the borders of said State; or (e) upon any vessel or aircraft of the United States; or (f) upon any other mobile stations within the jurisdiction of the United States, except under and in accordance with this Act and with a license in that behalf granted under the provisions of this Act.

SEC. 303. Except as otherwise provided in this Act, the Commission from time to time, as public convenience, interest, or necessity requires, shall—

(1) Have authority to prescribe the qualifications of station operators, to classify them according to the duties to be performed, to fix the forms of such licenses, and to issue them to such citizens of the United States as the Commission finds qualified;

(m) (1) Have authority to suspend the license of any operator upon proof sufficient to satisfy the Commission that the licensee—

(A) Has violated any provision of any Act, treaty, or convention binding on the United States which the Commission is authorized to administer, or any regulation made by the Commission under any such Act, treaty, or convention; or

(B) Has failed to carry out a lawful order of the master or person lawfully in charge of the ship or aircraft on which he is employed; or

(C) Has willfully damaged or permitted radio apparatus or installations to be damaged; or

(D) Has transmitted superfluous radio communications or signals or communications containing profane or obscene words, language, or meaning, or has knowingly transmitted—

(1) False or deceptive signals or communications, or

(2) A call signal or letter which has not been assigned by proper authority to the station he is operating; or

(E) Has willfully or maliciously interfered with any other radio communications or signals; or

(F) Has obtained or attempted to obtain, or has assisted another to obtain or attempt to obtain, an operator's license by fraudulent means.

(2) No order of suspension of any operator's license shall take effect until fifteen days' notice in writing thereof, stating the cause for the proposed suspension, has been given to the operator licensee who may make written application to the Commission at any time within said fifteen days for a hearing upon such order. The notice to the operator licensee shall not be effective until actually received by him, and from that time he shall have fifteen days in which to mail the said application. In the event that physical conditions prevent mailing of the application at the expiration of the fifteen-day period, the application shall then be mailed as soon as possible thereafter, accompanied by a satisfactory explanation of the delay. Upon receipt by the Commission of such application for hearing, said order of suspension shall be held in abeyance until the conclusion of the hearing which shall be conducted under such rules as the Commission may prescribe. Upon the conclusion of said hearing the Commission may affirm, modify, or revoke said order of suspension.

(n) Have authority to inspect all radio installations associated with stations required to be licensed by any Act or which are subject to the provisions of any Act, treaty, or convention binding on the United States, to ascertain whether in construction, installation, and operation they conform to the requirements of the rules and regulations of the Commission, the provisions of any Act, the terms of any treaty or convention binding on the United States, and the conditions of the license or other instrument of authorization under which they are constructed, installed, or operated.

(r) Make such rules and regulations and prescribe such restrictions and conditions, not inconsistent with law, as may be necessary to carry out the provisions of this Act, or any international radio or wire communications treaty or convention, or regulations annexed thereto, including any treaty or convention insofar as it relates to the use of radio, to which the United States is or may hereafter become a party.

SEC. 318. The actual operation of all transmitting apparatus in any radio station for which a station license is required by this Act shall be carried on only by a person holding an operator's license issued hereunder, and no person shall operate any such apparatus in such station except under and in accordance with an operator's license issued to him by the Commission: *Provided, however, That the Commission if it shall find that the public interest, convenience, or neces-*

## RADIO OPERATING QUESTIONS AND ANSWERS

sity will be served thereby may waive or modify the foregoing provisions of this section for the operation of any station except (1) stations for which licensed operators are required by international agreement, (2) stations for which licensed operators are required for safety purposes, (3) stations engaged in broadcasting and (4) stations operated as common carriers on frequencies below thirty thousand kilocycles: *Provided further*, That the Commission shall have power to make special regulations governing the granting of licenses for the use of automatic radio devices and for the operation of such devices.

SEC. 321. (a) The transmitting set in a radio station on shipboard may be adjusted in such a manner as to produce a maximum of radiation, irrespective of the amount of interference which may thus be caused, when such station is sending radio communications or signals of distress and radio communication relating thereto.

(b) All radio stations, including Government stations and stations on board foreign vessels when within the territorial waters of the United States, shall give absolute priority to radio communications or signals relating to ships in distress; shall cease all sending on frequencies which will interfere with hearing a radio communication or signal of distress, and, except when engaged in answering or aiding the ship in distress, shall refrain from sending any radio communications or signals until there is assurance that no interference will be caused with the radio communications or signals relating thereto, and shall assist the vessel in distress, so far as possible, by complying with its instructions.

SEC. 322. Every land station open to general public service between the coast and vessels or aircraft at sea shall, within the scope of its normal operations, be bound to exchange radio communications or signals with any ship or aircraft station at sea; and each station on shipboard or aircraft at sea shall, within the scope of its normal operations, be bound to exchange radio communications or signals with any other station on shipboard or aircraft at sea or with any land station open to general public service between the coast and vessels or aircraft at sea: *Provided*, That such exchange of radio communication shall be without distinction as to radio systems or instruments adopted by each station.

SEC. 325. (a) No person within the jurisdiction of the United States shall knowingly utter or transmit, or cause to be uttered or transmitted, any false or fraudulent signal of distress, or communica-

### APPENDIX III

tion relating thereto, nor shall any broadcasting station rebroadcast the program or any part thereof of another broadcasting station without the express authority of the originating station.

SEC. 326. Nothing in this Act shall be understood or construed to give the Commission the power of censorship over the radio communications or signals transmitted by any radio station, and no regulation or condition shall be promulgated or fixed by the Commission which shall interfere with the right of free speech by means of radio communication. No person within the jurisdiction of the United States shall utter any obscene, indecent, or profane language by means of radio communication.

SEC. 358. The radio installation, the operators, the regulation of their watches, the transmission and receipt of messages, and the radio service of the ship except as they may be regulated by law or international agreement, or by rules and regulations made in pursuance thereof, shall in the case of a ship of the United States be under the supreme control of the master.

SEC. 501. Any person who willfully and knowingly does or causes or suffers to be done any act, matter, or thing, in this Act prohibited or declared to be unlawful, or who willfully and knowingly omits or fails to do any act, matter, or thing in this Act required to be done, or willfully and knowingly causes or suffers such omission or failure, shall, upon conviction thereof, be punished for such offense, for which no penalty (other than a forfeiture) is provided herein, by a fine of not more than \$10,000 or by imprisonment for a term of not more than two years, or both.

SEC. 502. Any person who willfully and knowingly violates any rule, regulation, restriction, or condition made or imposed by the Commission under authority of this Act, or any rule, regulation, restriction, or condition made or imposed by any international radio or wire communications treaty or convention, or regulations annexed thereto, to which the United States is or may hereafter become a party, shall, in addition to any other penalties provided by law, be punished, upon conviction thereof, by a fine of not more than \$500 for each and every day during which such offense occurs.

SEC. 605. No person receiving or assisting in receiving, or transmitting, or assisting in transmitting, any interstate or foreign communication by wire or radio shall divulge or publish the existence, contents, substance, purport, effect, or meaning thereof, except

through authorized channels of transmission or reception, to any person other than the addressee, his agent, or attorney, or to a person employed or authorized to forward such communication to its destination, or to proper accounting or distributing officers of the various communicating centers over which the communication may be passed, or to the master of a ship under whom he is serving, or in response to a subpoena issued by a court of competent jurisdiction, or on demand of other lawful authority; and no person not being authorized by the sender shall intercept any communication and divulge or publish the existence, contents, substance, purport, effect, or meaning of such intercepted communication to any person; and no person not being entitled thereto shall receive or assist in receiving any interstate or foreign communication by wire or radio and use the same or any information therein contained for his own benefit or for the benefit of another not entitled thereto; and no person having received such intercepted communication or having become acquainted with the contents, substance, purport, effect, or meaning of the same or any part thereof, knowing that such information was so obtained, shall divulge or publish the existence, contents, substance, purport, effect, or meaning of the same or any part thereof, or use the same or any information therein contained for his own benefit or for the benefit of another not entitled thereto: *Provided*, That this section shall not apply to the receiving, divulging, publishing, or utilizing the contents of any radio communication broadcast, or transmitted by amateurs or others for the use of the general public, or relating to ships in distress.

**INTERNATIONAL TELECOMMUNICATION CONVENTION,  
MADRID, 1932**

**ARTICLE 24**

§1. The contracting governments agree to take all the measures possible, compatible with the system of telecommunication used, with a view to insuring the secrecy of international correspondence.

**ARTICLE 34**

§1. Stations carrying on radio communications in the mobile service shall be bound, within the scope of their normal operation, to exchange radio communications with one another irrespective of the radio system they have adopted.

## APPENDIX III

### ARTICLE 35

§1. All stations, regardless of their purpose, must, so far as possible, be established and operated in such a manner as not to interfere with the radio services or communications of either the other contracting governments, or the private operating agencies recognized by these contracting governments and of other duly authorized operating agencies which carry on radio-communication service.

### ARTICLE 36

Stations participating in the mobile service shall be obliged to accept, with absolute priority, distress calls and messages regardless of their origin, to reply in the same manner to such messages, and immediately to take such action in regard thereto as they may require.

### ARTICLE 37

The contracting governments agree to take the steps required to prevent the transmission or the putting into circulation of false or deceptive distress signals or distress calls, and the use, by a station, of call signals which have not been regularly assigned to it.

## GENERAL RADIO REGULATIONS (CAIRO REVISION, 1938)

Annexed to the International Telecommunications Convention  
(Madrid 1932)

### ARTICLE 2

44 The administrations agree to take the necessary measures to prohibit and prevent:

45 (a) the unauthorized interception of radio communications not intended for the general use of the public;

46 (b) the divulging of the contents or of the mere existence, the publication or any use whatever, without authorization, of the radio communication mentioned in No. 45.

### ARTICLE 3

47 §1. (1) No transmitting station may be established or operated by any person or by any enterprise whatever without a special license issued by the government of the country to which the station in question is subject.

ARTICLE 6

69 §1. The waves emitted by a station must be kept on the authorized frequency as exactly as the state of the art permits, and their radiation must be as free as practically possible from all emissions not essential to the type of communication carried on.

71 §2. (1) The state of the art in the various cases of operation is defined in appendixes 1, 2, and 3, concerning the exactitude of the frequency, the level of harmonics, and the width of the frequency band occupied.

76 §3. (1) The administrations shall frequently check the waves emitted by the stations under their jurisdiction to determine whether or not they comply with the provisions of the present Regulations.

ARTICLE 9

203 §2. The frequency of emission of mobile stations shall be verified as often as possible by the inspection service to which they are subject.

ARTICLE 11

276 §1. The radio service of a mobile station shall be placed under the supreme authority of the master or the person responsible for the ship, aircraft, or any other vehicle carrying the mobile station.

278 §3. The master or responsible person as well as any persons who may have knowledge of the text or simply the existence of radio-telegrams, or of any information acquired by means of the radio service, shall be bound by the obligation to observe and insure the secrecy of the correspondence.

ARTICLE 12

279 §1. (1) The competent governments or administrations of countries, where a mobile station calls, may demand the production of the license. The operator of the mobile station or the person responsible for the station must submit to this verification. The license must be kept in such a way that it may be furnished without delay. However, the production of the license may be replaced by a permanent posting in the station, of a copy of the license certified by the authority which has granted it.

## APPENDIX III

### ARTICLE 17

374 §2. (1) Before transmitting, any station must keep watch over a sufficient interval to assure itself that it will cause no harmful interference with the transmissions being made within its range; if such interference is likely, the station shall await the first stop in the transmission which it may disturb.

### ARTICLE 22

525 §1. (1) The transmission of unnecessary or unidentified signals or correspondence shall be forbidden to all stations.

527 (2) Tests and experiments shall be permitted in mobile stations if they do not interfere with the service of other stations. As for stations other than mobile stations, each administration shall judge, before authorizing them, whether or not the proposed tests or experiments are likely to interfere with the service of other stations.

### ARTICLE 24

542 1. No provision of these Regulations shall prevent a mobile station in distress from using any means available to it for drawing attention, signalling its position, and obtaining help.

548 3. (2) Aircraft. Any aircraft in distress must transmit the distress call on the watching-wave of the land or mobile stations capable of helping it; when the call is addressed to stations of the maritime service, the waves to be used are the distress-wave or watching-wave of these stations.

549 §4. (1) In radiotelegraphy, the distress signal shall consist of the group ... — — — ., transmitted as one signal, in which the dashes must be emphasized so as to be distinguished clearly from the dots.

550 In radiotelephony, the distress signal shall consist of the spoken expression Mayday (corresponding to the French pronunciation of the expression "m'aidez").

551 (2) These distress signals shall announce that the ship, aircraft, or any other vehicle which sends the distress signal is threatened by serious and imminent danger and requests immediate assistance.

555 §5. (4) This call shall have absolute priority over other transmissions. All stations hearing it must immediately cease all transmission capable of interfering with the distress traffic and must

## RADIO OPERATING QUESTIONS AND ANSWERS

listen on the wave used for the distress call. This call must not be sent to any particular station and shall not require an acknowledgment of receipt.

556 (1) The distress call must be followed as soon as possible by the distress message. This message shall include the distress call followed by the name of the ship, aircraft, or the vehicle in distress, information regarding the position of the latter, the nature of the help requested, and any other further information which might facilitate this assistance.

557 (2) When, in its distress message, an aircraft is unable to signal its position, it shall endeavor after the transmission of the incomplete message to send its call signal long enough so that the radio direction-finding stations may determine its position.

558 (1) As a general rule, a ship or aircraft at sea shall signal its position in latitude and longitude (Greenwich) using figures, for the degrees and minutes, accompanied by one of the words North or South and one of the words East or West. A period shall separate the degrees from the minutes. In some cases, the true bearings and the distance in nautical miles from some known geographical point may be given.

560 (3) As a general rule, an aircraft flying over land shall signal its position by the name of the nearest locality, its approximate distance from this point, accompanied, according to the case, by one of the words North, South, East, or West, or, in some cases, words indicating intermediate directions.

561 §8. The distress call and message shall be sent only by order of the master or person responsible for the ship, aircraft, or other vehicle carrying the mobile station.

569 §11. (1) Stations of the mobile service which receive a distress message from a mobile station which is unquestionably in their vicinity, must acknowledge receipt thereof at once (see Nos. 587, 588, and 589). If the distress call has not been preceded by an auto-alarm signal, these stations may transmit this auto-alarm signal with the authorization of the authority responsible for the station (for mobile stations, see No. 276), taking care not to interfere with the transmission of the acknowledgment of the receipt of said message by other stations.

570 (2) Stations of the mobile service which receive a distress message from a mobile station which unquestionably is not in their vicinity, must wait a short period of time before acknowledging

### APPENDIX III

receipt thereof, in order to make it possible for stations nearer to the mobile station in distress to answer and acknowledge receipt without interference.

573 §14. The control of distress traffic shall devolve upon the mobile station in distress or upon the mobile station which, by application of the provisions of No. 567, has sent the distress call. These stations may delegate the control of the distress traffic to another station.

604 §22. (2) In radiotelephony the urgent signal shall consist of three transmissions of the expression PAN (corresponding to the French pronunciation of the word "panne"); it shall be transmitted before the call.

605 (3) The urgent signal shall indicate that the calling station has a very urgent message to transmit concerning the safety of a ship, an aircraft, or another vehicle, or concerning the safety of some person on board or sighted from on board.

606 (4) In the aeronautical service, the urgent signal PAN shall be used in radiotelegraphy and in radiotelephony to indicate that the aircraft transmitting it is in trouble and is forced to land, but that it is not in need of immediate help. This signal should, so far as possible, be followed by a message giving additional information.

607 (5) The urgent signal shall have priority over all other communications, except distress communications, and all mobile or land stations hearing it must take care not to interfere with the transmission of the message which follows the urgent signal.

608 (6) In case the urgent signal is used by a mobile station, this signal must, as a general rule, subject to the provisions of No. 606, be addressed to a definite station.

612 §25. (1) The urgent signal may be transmitted only with the authorization of the master or of the person responsible for the ship, aircraft, or any other vehicle carrying the mobile station.

613 (2) In the case of a land station, the urgent signal may be transmitted only with the approval of the responsible authority.

615 §26. (1) In radiotelegraphy, the safety signal shall consist of the group TTT, transmitted three times, with the letters of each group, as well as the consecutive groups, well separated. This signal shall be followed by the word DE and three transmissions of the call signal of the station sending it. It announces that this station is about to transmit a message concerning the safety of navigation or giving important meteorological warnings.

## RADIO OPERATING QUESTIONS AND ANSWERS

616 (2) In radiotelephony, the word Security (corresponding to the French pronunciation of the word "sécurité") repeated three times, shall be used as the safety signal.

619 §28. (2) All stations hearing the safety signal must continue listening on the wave on which the safety signal has been sent until the message so announced has been completed; they must moreover keep silence on all waves likely to interfere with the message.

### ARTICLE 26

#### *Order of Priority of Communications in the Mobile Service*

653. The order of priority of radio communications in the mobile service shall be as follows:

1. Distress calls, distress messages, and distress traffic;
2. Communications preceded by an urgent signal;
3. Communications preceded by a safety signal;
4. Communications relative to radio direction-finding bearings;
5. Government radiotelegrams for which priority right has not been waived;
6. All other communications.

## APPENDIX IV

### AMERICAN STANDARD GRAPHICAL SYMBOLS FOR TELEPHONE, TELEGRAPH, RADIO, AND ELECTRONIC DEVICES\*

#### 1. Symbol Components

1.01. Adjustable {see Contact  
                  {see also Variable

1.02. Air core (see Core)

1.03. Coil (see Winding)

1.04. Contact

1.0401. Adjustable or sliding contact or regular contact for relays, keys, jacks, etc.

1.0402. Moving contact or armature for relays, non-locking keys, jacks, etc. (circle indicates pivot point and is always shown on moving contacts)

1.0403. Moving contact for locking keys, jacks, etc. (circle indicates pivot point and is always shown on moving contacts)

1.0404. Vibrator

    Reed

    Use only one dash

    Split Reed

1.0405. Sleeve

1.0406. Insulator for mechanical coupling between

moving contacts on jacks, relays, keys, etc.

1.0407. Adaptations of contacts and mechanical coupling

    Make

    Break

    Transfer

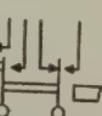
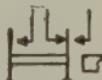
    Relay combination make-break-make

    Relay combination make-break-make

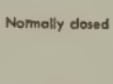
    Relay combination with mechanical coupling

    Normally open

    Normally closed



Note: Where simple contacts only are involved, the following symbols are acceptable:



\* Reproduced by Courtesy American Standards Association.

## RADIO OPERATING QUESTIONS AND ANSWERS

### 1.05. Core

1.051. Air (no symbol; indicate air core when required)

1.052. Magnetic (general) 

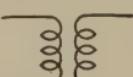
1.053. Relay or Magnet 

1.054. Adaptations

air-core inductor



Air-core transformer



Magnetic-core inductor



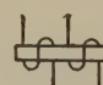
Magnetic-core transformer



Single-winding relay



Double-winding relay



### 1.06. Heater Element

Note: To be used where heat-producing elements are required as in thermostats, constant-temperature chambers, etc.

### 1.07. Inductive Winding (see Winding)

### 1.08. Inner End of Winding (see Winding)

### 1.09. Iron Core (see Core)

### 1.10. Moving Contact (see Contact)

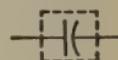
### 1.11. Noninductive Winding (see Winding)

### 1.12. Shielding

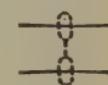
1.121. General 

1.122. Adaptations

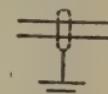
Shielded capacitor



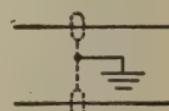
Shielded wires



Shielded wires with shield grounded



Shielded wires with shield grounded



### 1.13. Variable

1.131. General 

1.132. Adaptations

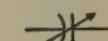
Variable or adjustable inductor



Variable or adjustable resistor



Variable or adjustable capacitor



### 1.14. Winding

1.141. Inductive



1.142. Noninductive



1.143. Dot indicates inner end of winding



1.144. Adaptations

## APPENDIX IV

Relay with windings brought out to individual terminals



brought out to a common terminal

Relay with certain windings internally connected and



Relay with certain windings internally connected and brought out to common terminals



### 2. Basic Symbols and Adaptations

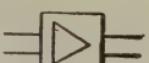
2.01. Aerial (see Antenna)  
 2.02. Alarm fuse (see Protection)  
 2.03. Ammeter (see Meter)  
 2.04. Ampere-hour Meter (see Meter)

2.05. Amplifier

2.051. For use in single-line diagrams



2.052. Where more leads are shown



2.06. Antenna

2.061. Aerial



2.062. Counterpoise



2.063. Loop

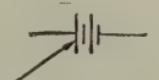


2.07. Arrester (see Protection)  
 2.08. Autotransformer (see Inductor)

2.09. Ballast Lamp (see Lamp)

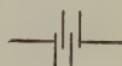
2.10. Battery

2.101. General (the long line is always positive but in



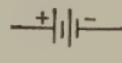
cases of uncertainty, polarity may be indicated)

2.102. Counter EMF

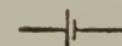


2.103. Adaptations

With polarity indicated



One cell



Multicells



\*Several voltages on one circuit

"X" Voltage

\* (Where it is desired to indicate different voltages in same circuit, indicate by changes in number of cell sections as illustrated)

"Y" Voltage

"Z" Voltage

2.11. Bell (see Signal)

2.12. Binding Post (see Terminal)

2.13. Buzzer (see Signal)

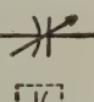
2.14. Capacitor

2.141. Fixed

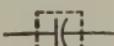


2.142. Adaptations

Variable or adjustable



Shielded

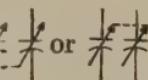


# RADIO OPERATING QUESTIONS AND ANSWERS

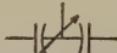
Variable differential



With mechanical linkage of units



Split-stator



Note: Where it is necessary to identify the capacitor electrodes, the curved element shall represent the outside electrode in fixed paper-dielectric and ceramic-dielectric capacitors, the negative electrode in electrolytic capacitors and the moving element in variable and adjustable capacitors. When it is desired to especially distinguish trimmer capacitors, the letter "T" should appear adjacent to the symbol.

2.15. Circuit Breaker (see Protection)

2.16. Coils (see Inductor)

2.17. Condenser (see Capacitor)

2.18. Connecting Block (see Terminal)

2.19. Counterpoise (see Antenna)

2.20. Crystal

2.201. Detector



2.202. Piezoelectric



2.21. Dial

2.211. Typical  
(Use springs and contacts as required)



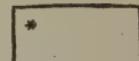
2.22. Drop (see Signal)

2.23. Fuse (see Protection)

2.24. Galvanometer (see Meter)

2.25. General

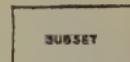
2.251.



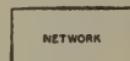
\* In all cases indicate type of apparatus; symbol to be used where internal details need not be shown.

2.252. Adaptations

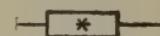
Subset



Network



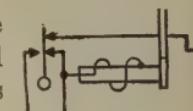
Resistor, fixed



\* This symbol must always be used with an identifying legend within or adjacent to the rectangle.

2.26. Generator (hand)

Typical (Use springs and contacts as required)



2.27. Ground



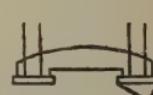
2.28. Hand Set

2.281. Three-conductor

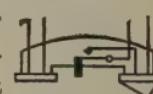


2.282. Adaptations

Four-conductor



Four-conductor with transmitter cutout key



2.29. Head Set (see Receiver)

2.30. Heat Coil (see Protection)

## APPENDIX IV

2.31. Horn (see Loud-speaker)  
 2.32. Howler (see Loud-speaker)  
 2.33. Illuminating Lamp (see Lamp)  
 2.34. Inductor (see also Relay)  
 2.341. Fixed



Note: Wherever the above symbol has been used in this standard, it is also acceptable to use the following symbol:

2.342. Adaptations

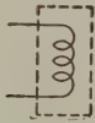
Air core



Variable or adjustable



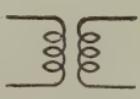
Shielded



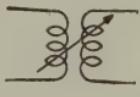
Magnetic core



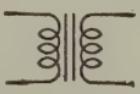
Transformer



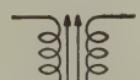
Transformer  
(variable or adjustable)



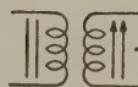
Transformer  
(magnetic core)



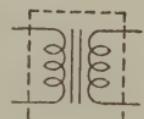
Transformer  
(variable core)



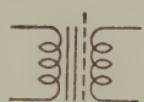
Transformer  
(variable core  
in one winding  
only)



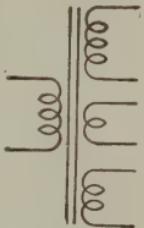
Transformer  
(magnetic core  
and shielding)



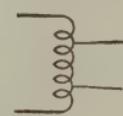
Transformer  
(magnetic core  
and shielding  
on one winding  
only)



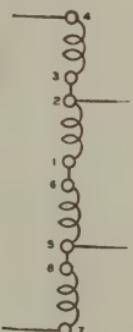
Transformer (mag-  
netic core multi-  
winding)



Autotransformer



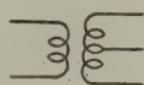
Autotransformer  
(terminals and  
designations are  
shown only when  
terminals require  
identification)



Transformer (un-  
equal ratio)      Low      High

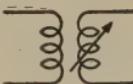


Transformer  
(with tapped  
winding)



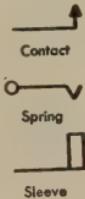
## RADIO OPERATING QUESTIONS AND ANSWERS

Transformer  
(variable coupling. Position of arrow indicates moving coil)



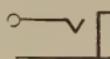
### 2.35. Jack

2.351. Components (assemble as required)

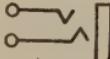


### 2.352. Adaptations

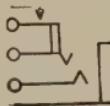
Two-conductor



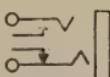
Three-conductor



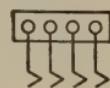
Three-conductor  
(with auxiliary contacts)



Series—three-conductor

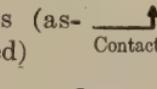


Gang



### 2.36. Key

2.361. Components (assemble as required)



### 2.362. Telegraph key

2.3621. Simple



2.3622. Closed-circuit

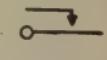


2.3623. Open-circuit or pole-changing

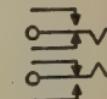


### 2.363. Adaptations

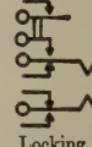
Nonlocking



Locking



Typical lever-type combined locking and non-locking key, with auxiliary contacts



Nonlocking

### 2.37. Lamp

2.371. Switchboard



2.372. Illuminating



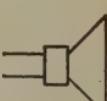
2.373. Ballast or resistance



2.38. Loop (see Antenna)

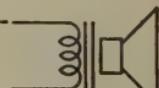
2.39. Loud-speaker, Horn or Howler

2.391. General



2.392. Adaptations

Magnetic armature



## APPENDIX IV

Permanent magnet, with moving coil		Double-button	
Electromagnetic, with moving coil		Condenser	
Electromagnetic, with moving coil and hum-neutralizing winding		Moving-coil	
2.40. Magneto (see Generator Hand)		Velocity	
2.41. Message Register		Crystal	
2.42. Meter		2.44 Network	
2.421. General symbol		2.441. General	
* Abbreviations to identify the specific type of meter		2.442. Adaptations	
For example:		* Specific arrangement	
A—Ammeter		* Apparatus represented by the rectangles will be designated inside of each.	
AH—Ampere hour		Specific arrangement	
F—Frequency		2.45. Pickup (see Reproducer)	
G—Galvanometer		2.46. Piezoelectric Crystal (see Crystal)	
MA—Milliammeter		2.47. Plug (see also Receptacle)	
PF—Power factor		2.471. Typical switch-board plug—two-conductor	
TT—Total time		2.472. Typical switch-board plug—three-conductor	
V—Voltmeter		2.473. Gang	
VA—Volt-ammeter			
W—Wattmeter			
WH—Watt hour			
$\mu$ A—Microammeter			
2.43. Microphone (see also Transmitter)			
2.431. General			
2.432. Adaptations			
Single-button			

## RADIO OPERATING QUESTIONS AND ANSWERS

2.474. Nonpolarized (number of terminals as required)



2.475. Polarized (number of terminals as required)



2.476. Three-conductor, polarized



Radial prong indicates polarization

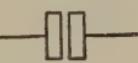
2.48. Protection

2.481. Arrester or protector

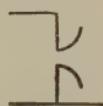
2.4811. General



2.4812. Carbon block



2.4813. Horn gap



2.482. Circuit breaker



2.483. Fuse

2.4831. General



2.4832. Fuse mounted on bus bar

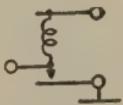


2.4833. Fuse mounted on protector mounting



2.484. Heat coil

2.4841. Heat coil and mounting



2.49. Receiver

2.491. General



2.492. Hand



2.493. Single headset.



2.494. Double headset

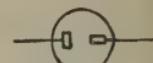


2.50. Receptacle (see also Plug)

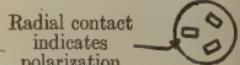
2.501. Nonpolarized (number of terminals as required)



2.502. Polarized (number of terminals as required)



2.503. Three-conductor, polarized



Radial contact indicates polarization

2.51. Rectifier

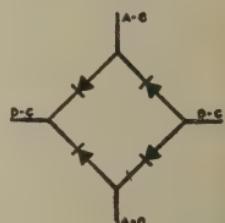
2.511. General (the arrow points in the direction of low resistance)

2.512. Adaptations

Half-wave



Full-wave



2.52. Regulator

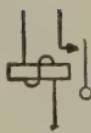
2.521. Centrifugal governor (contacts normally open or normally closed as required—shown here as normally closed)



## APPENDIX IV

### 2.53. Relay

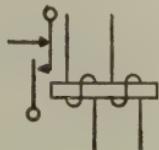
#### 2.531. With make contact



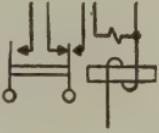
#### 2.532. With break contact



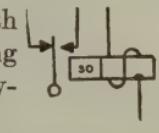
#### 2.533. Double winding with make-before-break contacts



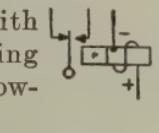
#### 2.534. Noninductive winding and transfer and make contacts



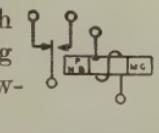
#### 2.535. Winding with specific operating feature (see following note)



#### 2.536. Winding with specific operating feature (see following note)



#### 2.537. Winding with specific operating feature (see following note)



Note: The proper poling for a polarized relay shall be shown by the use of + and - designations applied to the winding leads. The interpretation of this shall be that current in the direction indicated shall move or tend to move the armature toward the contact shown nearest the core on the schematic.

matic. If the relay is equipped with numbered terminals, the proper terminal numbers shall also be shown.

AC—indicates alternating current or ringing relay

D—indicates differential

DB—indicates double biased (Biased in both directions)

DP—indicates dashpot

EP—indicates electrically polarized

\*FO—indicates fast operate

\*FR—indicates fast release

MG—indicates marginal

NB—indicates no bias

NR—indicates nonreactive

P—indicates magnetically polarized, using biasing spring, or having magnet bias

SO—indicate slow operate

SR—indicates slow release

SW—indicates sandwich wound to improve balance to longitudinal currents

Any combination of the above may be used where a relay possesses more than one special feature.

\* Used where unusually fast operation or fast releasing is essential to the circuit operation.

### 2.54. Repeater

#### 2.541. Two-wire— for use in single-line diagrams



#### 2.542. Four-wire— for use in single-line diagrams



#### 2.543. Adaptations Two-wire where



## RADIO OPERATING QUESTIONS AND ANSWERS

more leads are shown



Four-wire where more leads are shown

Two-wire with by-pass for low-frequency ringer—for use in single-line diagrams



2.55. Repeating Coil (see Inductor)

2.56. Reproducer

2.561. General



2.562. Adaptations

Electromagnetic



Crystal



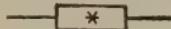
2.57. Resistance Lamp (see Lamp)

2.58. Resistor

2.581. Fixed

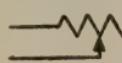


Where the above symbol has been used in this standard, it is also acceptable to use the following symbol:



\* This symbol must always be used with an identifying legend within or adjacent to the rectangle.

2.582. Adaptations



Variable or ad-  
justable—



two-wire, or rheostat

Variable or ad-  
justable—



three-wire, or voltage-  
divider

Tapped



Tapped three-lead or voltage-  
divider type



With terminals



2.59. Retardation Coil (see Inductor)

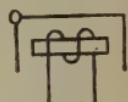
2.60. Rheostat (see Resistor)

2.61. Ringer (see Signal)

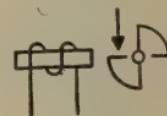
2.62. Signal

2.621. Annunciator drop or  
signal

2.6211. Shutter or  
grid type



2.6212. Ball  
type

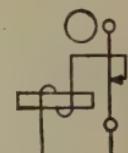


2.622. Bell

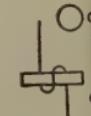
2.6221. Bell



2.6222. D-c bell



2.6223. A-c bell



## APPENDIX IV

2.623. Buzzer

2.6231. Buzzer



2.6232. D-c buzzer



2.6233. A-c buzzer



2.624. Drops

2.6241. Manually restored



2.6242. Electrically restored



2.625. Ringer



2.626. Solenoid

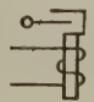


2.6261. Plunger type



2.63. Sounder—Telegraph

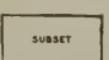
2.631. General



2.632. Adaptation with contact



2.64. Subset



2.65. Switch

2.651. Centrifugal (see Regulator)

2.652. Selector type

2.6521. 22-point selector

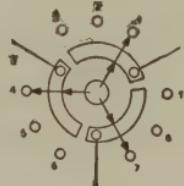


2.6522. 10-point selector

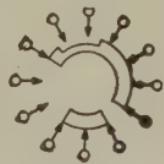


2.6523. Wafer

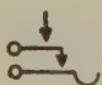
Typical viewed from end opposite control knob



Typical viewed from end opposite control knob



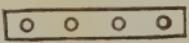
2.66. Switch Hook



2.67. Terminal

2.671. Terminal or binding post

2.672. Typical terminal strip or connecting block (number of terminals as required)



2.68. Terminal Strip (see Terminal)

2.69. Thermocouple

2.691. General



2.692. Thermoelement

2.6921. Indirectly heated



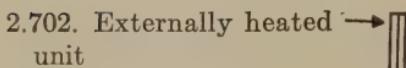
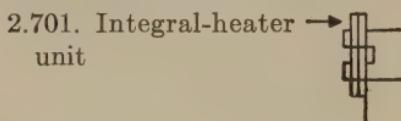
2.6922. Directly heated



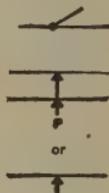
## RADIO OPERATING QUESTIONS AND ANSWERS

2.70. Thermo-cutout

2.754. Strap



2.755. Pair



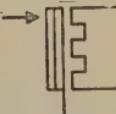
2.703. Self-heated unit



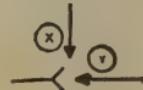
2.756. Splice



2.704. External-heater unit

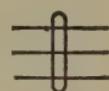


2.757. Conditional



2.71. Transformer (see Inductor)

2.758. Switchboard cable



2.72. Transmitter (see also Microphone)

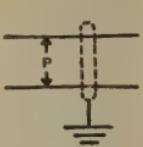
2.759. Duplex or quad-ded cable



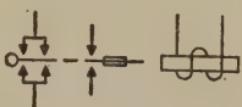
2.721. General



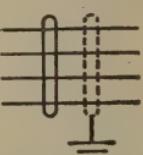
2.760. Adaptations  
Pair with shield grounded



2.73. Vibrator  
Typical



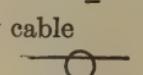
Cable with shield grounded



2.74. Voltage,  
Source of Alternating



2.761. Radio-frequency cable  
Coaxial

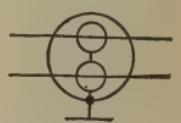


2.75. Wire

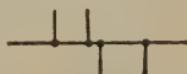
2.751. Crossing, not connected



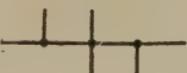
Twin coaxial



2.752. Connections (preferred)  
no use of crosses with connections



2.753. Connections



Twin-conductor



## APPENDIX IV

### 1. Component Symbols

1.01. Electrodes	1.013. Collecting
1.011. Emitting	1.0131. Anode or plate (including collector and fluorescent target)
1.0111. Directly heated cathode (filament type)	1.0132. Target, X-ray
1.0112. Indirectly heated cathode	1.014. Collecting and emitting
1.0113. Cold cathode (including ionic-heated cathode)	1.0141. Dynode
1.0114. Photoelectric cathode	1.02. Heater
1.0115. Pool cathode	1.03. Envelope (shell)
1.0116. Ionic-heated cathode with supplementary heater	1.031. High-vacuum
1.012. Controlling	1.032. Gas-filled <i>Located as convenient</i>
1.0121. Grid (including beam-confining or beam-forming electrodes)	1.04. Shield
1.0122. Deflecting, reflecting or repelling electrode (electrostatic type)	1.041. Within envelope
1.0123. Ignitor	1.05. Coupling
1.0124. Excitor (contactor type)	1.051. Loop coupling (electromagnetic type)
	1.06. Resonators
	1.061. Single-cavity envelope
	1.062. Double-cavity envelope

### 2. Typical Application of Symbols

#### 2.01. General Notes

2.0101. The diagram for a tube having more than one heater shall show only one heater

symbol (inverted V) unless the heaters have entirely separate connections. If a tap is made, one heater symbol

## RADIO OPERATING QUESTIONS AND ANSWERS

shall still be shown, and the tap shall be shown at the vertex of the heater symbol, regardless of the actual division of voltage across the heater.

2.0102. Item 2.0101 shall apply also to filaments. In case of a tap, either brought out to a pin connection or internally connected as to a suppressor grid, the tap shall be shown at the vertex of the filament symbol, regardless of the actual division of voltage across the filament.

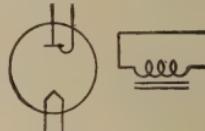
2.0103. A type having more than one cathode shall be shown as having a single cathode unless separate cathode connections are made.

2.0104. A type having two or more grids tied internally shall be shown with symbols for each grid, except when the grids are adjacent in the tube structure. Thus the diagram for a twin pentode having a common screen-grid connection for each section and for a converter tube having the No. 3 and No. 5 grids connected internally will show separate symbols for each grid. However, a triode where the control grid is physically in the form of two grid windings would show only one grid.

2.0105. A type having a grid adjacent to a plate but internally connected to the plate to form a portion of it shall be shown as having a plate only.

2.0106. Associated parts of a circuit such as deflecting coils,

field coils, etc., are not a part of the tube symbol but may be added to the circuit in the form of standard symbols. For example, resonant-type magnetron plus symbol for ferromagnetic inductor would be shown



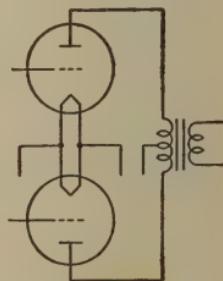
2.02. Triode with Filamentary Cathode



2.03. Triode with Indirectly Heated Cathode and Envelope Connection



2.04. This Figure Illustrates How Tube Symbols May Be Placed in Any Convenient Position as Shown in a Communication Transformer Circuit



2.05. Pentode (suppressor or beam-confining electrodes)



2.06. Diode (cold-cathode and gas content)



## APPENDIX IV

2.07. Phototube



2.08. Cathode-ray Tubes

2.081. With electrostatic deflection



2.082. For magnetic deflection



2.09. Mercury-pool Tubes

2.091. With ignitor and control grid



2.092. With excitor, control grid, and holding anode



2.10. Magnetron Tubes

2.101. Resonant type



2.102. Transit-time split-plate type with stabilizing deflecting electrodes and internal circuit



2.11. Velocity-modulation (velocity-variation) Tubes

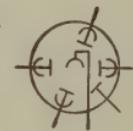
2.111. Single-cavity with reflecting electrode



2.112. Double-cavity with collecting electrode



2.12. Phototube (multiplier type)

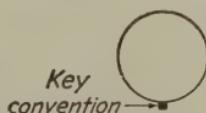


### 3. Tube-basing Conventions

3.01. Basing Orientation Symbols

3.011. For

tubes with  
keyed bases

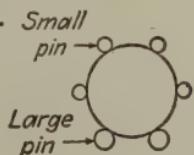


3.012. For tubes with  
bayonets, bosses, and  
other reference points

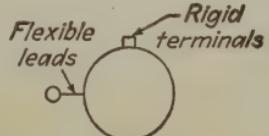


3.02. Tube Terminals

3.021. Base ter-  
minals



3.022. Envelope terminals

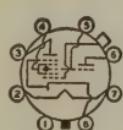


3.03. General Application

Triode with indirectly  
heated cathode and  
envelope connected  
to base terminal



Triode-heptode with  
rigid envelope con-  
nection





# INDEX OF DIAGRAMS AND ILLUSTRATIONS

## ELEMENT 2

FIGURE	PAGE
2-1. Simple series resonant wave trap . . . . .	30
2-2. Tuned-plate tuned-grid series-fed oscillator. . . . .	37
2-3. Hartley oscillators . . . . .	37
2-4. Armstrong tuned-grid shunt-fed oscillator . . . . .	38
2-5. Tuned-plate tuned-grid shunt-fed oscillator. . . . .	38
2-6. Triode-type crystal-controlled oscillator . . . . .	39
2-7. Colpitts shunt-fed oscillator . . . . .	39
2-8. Armstrong series-fed oscillator . . . . .	40
2-9. Electron-coupled oscillator. . . . .	40
2-10. Pentode-type crystal-controlled oscillator . . . . .	41
2-11. Loud-speaker coupling arrangement. . . . .	41
2-12. Loud-speaker coupling arrangement. . . . .	42
2-13. Resistance coupling. . . . .	42
2-14. Inductive or transformer coupling. . . . .	43
2-15. Impedance coupling. . . . .	43
2-16. Radio-frequency amplifier with capacity neutralization . . . . .	44
2-17. Plate neutralization system. . . . .	44
2-18. Grid neutralization system. . . . .	45
2-19. Antenna coupling systems . . . . .	45
2-20. Interstage coupling system. . . . .	46
2-21. Interstage coupling and neutralization. . . . .	46
2-22. Diode detector and audio-frequency amplifier. . . . .	47
2-23. Power or plate detection system . . . . .	47
2-24. Grid-leak detector. . . . .	48
2-25. Regenerative detector. . . . .	48
2-26. Radio-frequency doubling system. . . . .	49
2-27. Parallel resistance combination. . . . .	50
2-28. Series-parallel resistance combination . . . . .	50
2-29. Battery charging arrangement . . . . .	51
2-30. Shunt-rejector wave trap. . . . .	51
2-31. Series wave trap . . . . .	52
2-32. Underload circuit breaker . . . . .	52
2-33. Parallel resistance combination. . . . .	52
2-34. Shunt-wound motor, speed regulator, and starter . . . . .	53
2-35. Series resistance combination. . . . .	53

## RADIO OPERATING QUESTIONS AND ANSWERS

2-36. Carbon-microphone circuit arrangement . . . . .	54
2-37. Vacuum-tube operating-curve adjustments for class A, class B, and class C amplification . . . . .	62
2-38. Half-wave three-phase rectifier . . . . .	83
2-39. Bridge rectifier, single phase . . . . .	87
2-40. Full-wave single-phase rectifier . . . . .	87
2-41. Half-wave rectifier . . . . .	88
2-42. Simple crystal receiver . . . . .	111

### ELEMENT 3

3-1. Resistor network . . . . .	114
3-2. Voltage-divider network . . . . .	115
3-3. Plate-modulation system . . . . .	122
3-4. Carrier-wave envelope . . . . .	123
3-5. Microphone amplifier . . . . .	123
3-6. Suppressor-grid-modulation system . . . . .	124
3-7. Grid-modulation system . . . . .	125
3-8. Hertz-radiator coupling system . . . . .	135
3-9. Link coupling arrangement . . . . .	136
3-10. Push-pull neutralized radio-frequency amplifier . . . . .	136
3-11. Pentode plate-screen-modulated amplifier . . . . .	138
3-12. Dynatron oscillator . . . . .	151
3-13. Fundamental spark transmitter . . . . .	151
3-14. Fundamental oscillating arc . . . . .	152
3-15. Capacitative coupling system . . . . .	165
3-16. Loftin-White direct-coupled amplifier . . . . .	165

### ELEMENT 4

4-1. Three-phase wattmeter connections . . . . .	180
4-2. Delta-star or Y transformer . . . . .	184
4-3. Four-channel series-parallel mixer . . . . .	189
4-4. Parallel-fed amplifier system . . . . .	190
4-5. Line equalizer . . . . .	192
4-6. Grid-bias modulated class C radio-frequency amplifier with inductive coupling to the antenna . . . . .	195
4-7. Class B modulation system . . . . .	196
4-8. Cathode-ray trapezoidal pattern . . . . .	196
4-9. Simple carrier-shift indicator . . . . .	197
4-10. Capacitative coupling and harmonic suppression arrangement	204
4-11. Transmission-line coupling system . . . . .	205
4-12. Circuit for measuring antenna resistance . . . . .	206
4-13. Crystal-controlled oscillator with temperature-control unit and radio-frequency amplifier . . . . .	212

## INDEX OF DIAGRAMS AND ILLUSTRATIONS

4-14. Water-cooled tube with water-circulating system . . . . .	213
4-15. Correct ammeter connection in water-cooled system. . . . .	214
4-16. Balanced single-phase full-wave rectifier. . . . .	219
4-17. Filter networks. . . . .	221
4-18. Emergency connections for a defective three-phase transformer. . . . .	223
4-19. Multi-vibrator oscillator. . . . .	224
4-20. Simple shunt-fed plate arrangement. . . . .	229
4-21. Simple series-fed arrangement . . . . .	230

### ELEMENT 5

5-1. Grid-blocking keying system. . . . .	289
5-2. Key-click filters. . . . .	290
5-3. Transformer-primary keying system. . . . .	291

### ELEMENT 6

6-1. Dynamometer-type meter . . . . .	308
6-2. Types of radio-wave emissions . . . . .	311
6-3. Directional pattern of a loop antenna . . . . .	323
6-4. Directional pattern of a vertical antenna. . . . .	323
6-5. Arc back-shunt signalling system . . . . .	327
6-6. Marine self-rectifying transmitter circuit. . . . .	329
6-7. Unilateral characteristic. . . . .	337



## INDEX OF SUBJECTS

### A

Aeronautical station service, 173, 174  
Alternating current, correction factor of, 253  
    filament supply of, 63  
    Ohm's law on, 36  
    power calculation of, 309  
    problems in, 178-183  
    reactance value of, 118, 120  
Alternating-current ammeter, 92, 95, 308-309  
Alternating-current transformer, 119  
Alternator, output rating of, 254  
Ammeter, problems in, 94, 95  
    radio-frequency, 89, 90, 93, 309  
    remote, checking of, with antenna, 238  
    scale deflection of, 95  
    shunt, purpose of, 97  
        (*See also* Plate current)  
Ampere-hour meter, 92, 93  
Ampere turns, meaning of, 248  
Amplification factor, of tube, 58  
    relationship of, on voltage gain, 191  
Amplifier, applications for class A, 282  
    buffer, 137, 285  
    characteristics of, class A, 59, 62, 66  
    characteristics of, class B, 59, 62, 261

Amplifier, characteristics of, class C, 59, 62, 67, 268, 284  
degenerative feedback in, 191  
gain percentage in, 191, 231, 245  
harmonic reduction in, 282-283  
high-level, 189  
impedance-coupled, 41, 43  
Loftin-White, 165  
microphone, 123  
neutralized, 44, 45, 46, 286-287  
push-pull, 160-260  
radio-frequency, 44, 116, 132, 133, 162, 319  
    power of, 129, 130, 203  
resistance-coupled, 42  
transformer-coupled, 42, 43  
troubles of, 141, 202  
Amplitude, 18  
    modulation, 123, 125, 126, 130, 317  
Antenna, directional characteristics of, 110  
    dummy, 141, 214, 342  
excessive coupling effect of, on, 292, 343  
Hertz, 108, 121  
insulation of, 110  
loading of, 108, 323, 342  
loop, patterns of, 323, 337  
maximum-voltage point of, 345  
physical height of, 211  
physical length of, 108, 109  
power of, problems in, 207-211  
    ratios of, 317, 345

## RADIO OPERATING QUESTIONS AND ANSWERS

Antenna, resistance measurement of, 205, 206  
resonant frequency of, 121, 256, 323  
series condenser for, 108, 256, 323

Antenna ammeter, 238

Antenna coupling systems, 45, 135, 195, 204, 205

Antenna current, changes in, 130, 131, 200, 230, 268, 310, 317, 357

Apparent power, definition of, 254

Arc, electrode material, 328  
flash, in mercury-vapor tubes, 219  
fundamental oscillating, 152  
negative resistance of, 156  
oscillating, theory of, 280, 281

Arc transmitter, comparison of, with spark, 328  
frequency adjustment of, 326  
keying system for, 327  
use of hydrogen gas in, 326

Armstrong oscillator, 38, 40

Attenuator, mixer type, 189  
pad type, 188

Audio frequency (*see* Amplifiers)

Audio-peak limiter, use of, 228

Audio-transformer coupling, tetrode, 67, 261

Audio-tuned amplifier, 284

Auto-alarm, adjustments of, 337, 339  
frequency band, 340, 355  
operation of, 353, 354  
regulations for, 335  
testing of, 251  
troubles in, 335-337, 339, 340, 353

Auto-alarm signal, 349, 351, 360

Autodyne reception, 266

Automatic starter, failure of, 330

Automatic volume control, method of obtaining, 133, 266-267

Auxiliary antenna, 322

Auxiliary transmitter, 233, 234, 245

Average value, of a sine wave, 253, 254, 302

B

Battery, "A," substitution, 346  
"B," operating conditions, 71  
capacity changes in, 72  
care of, 276, 332  
determining charge of, 75  
effect of reversed charging polarity in, 75, 331  
heat generation in, 72  
methods of mixing solution for, 72  
problems in, 73, 332  
specific-gravity change in, 331  
storage, chemical composition of, 70, 71  
sulphation of, 75  
temperature effects on, 275, 276  
testing of, 73  
(*See also* Storage battery)

Beat-frequency, effect of, 226

Bias voltage, effect of, in audio class A amplifier, 66, 282  
factors determining, 67, 70, 160  
failure of, 217  
problems of, 263, 291, 341  
purpose of, in triode amplifier, 61  
(*See also* Grid)

Bias-voltage resistance, calculation of, 70

Bleeder resistances, 88, 149  
use of, 275, 342

Break-in relay, purpose of, 322  
use of, 324

Bridge-type rectifier, voltage output of, 82

## INDEX OF SUBJECTS

Buffer amplifier, purpose of, 137, 285  
By-pass condensers, open, 99  
By-pass condensers, shorted, 99, 341  
uses of, 103, 159, 160, 284

### C

Calculation, of alternating-current power, 309  
antenna power, 130, 207-209  
238, 309  
band width, 311  
impedance, 178, 180, 256, 302, 303  
modulation, 199, 200, 209, 310  
power, 24, 29, 30, 31, 35, 238,  
249, 250-252  
power factor, 25, 27, 117, 255  
resistance, 19, 20, 24, 28, 29, 30,  
93, 114, 115, 249, 252, 304

Call signals, 354

Calling procedure, 300

Capacitance, 21

of energy stored, 22, 33

(*See also* Capacity)

Capacitive coupling, 163, 164, 193, 202

Capacitive reactance, 21, 31

Capacity, of condensers, 32

connection, 32

formula for, 31

of input filter system, 85, 147,  
219, 333

problems in, 32

tube, neutralization of, 44-46

units of, 24

(*See also* Capacitance)

Carbon microphone, circuit dia-  
gram of, 54

construction of, 128

disadvantage of, 194

Carrier shift, causes of, 291  
definition of, 268, 316  
effect of, in transmitters, 140,  
141

indicator of, 195

negative, 141

positive, 202, 316

Cathode-ray patterns, for modula-  
tion, 194

Cells, voltage connection for, 19  
(*See also* Battery)

Censorship, 6

master's right of, 7

Characteristics, of choke coil, 116

class A amplifier, 59, 62

class B amplifier, 59, 62

class C amplifier, 59, 62, 245

comparative, of tubes, 55, 56, 61  
62, 89

diode detector, 259-260

dynatron oscillator, 157

electron-coupled oscillator, 157,  
247

filament emission, 258

filter systems, 85, 86, 88

grid-leak detector, 258

multivibrator, 158

plate detector, 259

power detector, 259

rectifier, 89

Charged bodies, positively and  
negatively, 115, 116

Charging, of battery, precautions  
in, 330, 332

polarity considerations in, 75

Chemicals, storage cell, 70, 71

Choke, cored, saturation of, 147,  
221, 272

filter, loose laminations in, 300

Heising, theory of, 314

input, in filters, 85, 86, 147, 333

open, effect of, 341-342

reluctance of, effect on, 147

## RADIO OPERATING QUESTIONS AND ANSWERS

Choke, resistance of, effect upon, 339, 340  
swinging, 86, 148, 149, 272

Choke coil, purpose of, 271, 315

Circuit breaker, underload, 52

Class A amplifiers, audio, application of, 282  
characteristics of, 59, 62, 66, 282  
definition of, 66  
distortion in, 60, 159, 341  
excitation of, 162, 283  
load-to-tube ratio in, 184

Class B amplifiers, advantage of, 198, 284  
audio-frequency, 260  
characteristics of, 59, 62, 261  
circuit requirements in, 161  
distortion in, 140  
modulator of, 129, 196, 212  
overloading in, 202, 300  
plate-current changes in, 200  
plate dissipation in, 200  
push-pull, audio, 260  
radio-frequency, 194, 212

Class C amplifiers, advantages of, 268-269  
application of, 283  
bias of, 160  
characteristics of, 59, 62, 67, 245, 268, 269  
coupling transformer of, calculation for, 228-229  
definition of, 284  
excitation of, 159, 262  
modulated, 137  
plate-current flow in, 142  
plate efficiency in, 161, 186  
in telegraph transmitters, 262

Clock, radio-room, 355

Code, transmission of, 240, 296

Coefficient, of coupling, problem in, 179

Coefficient, temperature, 152  
problem in, 291

Cold cathode rectifier, principle of, 84, 334, 335

Colpitts oscillator, comparison with Hartley oscillator, 138, 346

Commutator, care of, 103, 145, 273  
cleaning of, 103, 145, 273

Compass, magnetic, effect of electric current upon, 22

Condensers, capacity calculations for, 32  
coupling, effect of open, 99  
effect of shorted, 97

electrolytic, 274, 292

energy stored in, 22

equalizing resistor of, 149

filter, 86, 221, 333

microphone, 123

reactance calculations for, 21, 31, 117, 118, 300

voltage rating of, 275

Conductance, definition of, 26  
unit of, 25

Conduction of currents, in rectifier tubes, 89, 143

Conductors, resistance measurement of A types of, 21

Cooling system, tube, type of water used in, 217

Copper losses, in transformers, 182

Copper oxide rectifiers, 94  
limitations of, 96

Core, iron, use of, 305  
saturation of, 187, 221  
of transformer, construction of, 273

Correction factor, for meter, 253

Coulomb, definition of, 27

Coupling, antenna, 45, 135, 136, 195, 204, 292

capacitive, 45, 195, 204

coefficient of, problem in, 179

## INDEX OF SUBJECTS

Coupling, condenser, 97, 162  
direct system of, 164  
excessive, 292, 343  
Faraday-screen system of, 201  
impedance, 41, 43  
loud-speaker, 41, 42  
mutual, problem in, 179, 182  
optimum, 324  
parallel-feed, 190  
resistance, 42, 165, 260  
transformer, 42, 43  
transmission-line, 205  
unity, 163

Cross-talk interference, cause of, 247

Crystal, cleaning of, 154  
quartz, 154  
temperature effects in, 152, 153  
voltage application to, 279

Crystal detector, 262  
operation of, 111

Crystal filter, 267

Crystal oscillator, advantages of, 153, 277  
coupling effects in, 153, 278  
feedback requirements in, 301  
function of, 153, 278  
marine, 329  
oscillation tests for, 300  
power source for, 153, 277  
temperature coefficient of, 152, 278  
temperature control in, 153, 224, 225, 278

Current-carrying capacity, resistance to, 250

Current flow, in cells, 20  
electric, 18  
grid, 216, 315, 341  
measurement of, 24, 293, 307, 308

D

D'Arsonval meter, 91  
db (*see* Decibel)  
Damped wave, definition of, 111  
Dead-end losses, in an inductance, 265

Decibel, definition of, 26  
formula for, 231  
problems in, 198-200, 202

Decoupling networks, purpose of, 285, 359

Degenerative feedback, effect of, 191  
phase relation in, 191, 192

Delta-Y transformer, connected, 184, 247  
problems in, 181  
voltage output of, 247

wattmeter connections of, 180

Detectors, characteristics of, 134  
comparison of, 62  
crystal, operation of, 111  
types of, 262  
diode, theory of, 65  
grid-leak, theory of, 64, 65, 258, 318  
oscillation test of, in regenerative receivers, 318, 319  
plate, theory of, 65  
sensitivity of, 66

Deviation, of frequency, problem in, 292

Diaphragm, reasons for stretching, 194

Dielectric constants, 21

Diode detector, advantage of, 321  
comparison of, 62, 321  
theory of, 65, 259

Direction finder, antenna effect of, 338, 339  
bilateral, 338, 339  
directional characteristics of, 337

## RADIO OPERATING QUESTIONS AND ANSWERS

Direction finder, unilateral, 337-339  
vertical antenna, use of, in, 338  
(*See also* Loop antenna)

Direction-finding stations, 355

Distortion, causes of, in amplifiers, 160, 341

Distress, frequency, 11, 348, 350, 360

Distress message, 1, 10, 12, 350

Distress signal, 11, 171, 295, 296

Distress traffic, 17, 348, 350, 360

Distress transmitter adjustment, 5, 8

Doubler, frequency, method of obtaining, 215  
operating factors in, 262  
purpose of, 285, 344  
theory of, 67, 137, 285-286

Dummy antenna, definition of, 214  
purpose of, 141, 342

Dynamic instability, 125

Dynamic microphone, 126, 194

Dynamometer, 92

Dynamotor, uses of, 306  
voltage regulation of, 220, 306

Dynatron oscillator, 288  
characteristics of, 157  
operation of, 279, 280

**E**

Eddy currents, definition of, 120, 302  
in transformers, 273

Edison-type cells, capacity changes in, 72  
charging requirements of, 331  
determining the charge in, 74, 331  
testing of, 276  
voltage of, 73

Educational broadcast stations, 234

Effective value, of a sine wave, 117, 253, 254, 302

Efficiency, in class A amplifiers, 215  
in grid-bias modulated amplifier, 202, 313  
in modulated amplifiers, 313-314  
plate, problems in, 208, 215  
power transformer, 256  
problems in, 182, 216, 217  
in rectifier tube, 334-335  
(*See also* Plate efficiency)

Efficiency factors, 246

Electrolyte, equipment using, 248  
meaning of, 248  
in storage cells, 276

Electrolytic condenser, desirable feature of, 301  
operation of, 274, 275

Electromagnets, equipment using, 248

Electromotive force, measurement of, 24  
circuit diagram of, 40  
theoretical operation of, 280

Electrostatic shielding, purpose of, 289  
use of, 188, 203

Emergency equipment tests, 356

Emergency operation, 2

Emergency storage battery, gravity test, 356  
problems in, 332  
troubles in, 333

Emission, characteristics of, 311  
filament, characteristics of, 258  
secondary, 58  
types of, 170, 233, 242, 294, 311, 324

Energy, formula for, 22, 118  
radio-frequency indicators, 293  
side-band, 197  
stored in an inductance, 118

## INDEX OF SUBJECTS

Equalizer, line, 192  
    purpose of, 192  
    resistance in, 149, 342

Evaporation, in storage cells, 276

Excitation, 281, 313  
    of a class A amplifier, 59, 162  
    of a class B amplifier, 59, 162, 230  
    of a class C amplifier, 59, 68  
    excessive, effects of, 162, 300, 315  
    insufficient, effects of, 262  
    shock, 269

Experimental period, definition of, 237, 239

Experimental station, use of, 175, 299

F

False calls, 5

False signals, 5

Faraday screen, purpose of, 140  
    201

Feedback, adjustment of, 132, 133  
    crystal oscillator, requirements  
    of, 301  
    degenerative, 190, 191  
        (See also Regeneration)

Field intensity (*see* Field strength)

Field strength, measurement of,  
    problem in, 204, 208  
    turns, effect upon, 22  
    unit of, 204

Filament, circuit requirements of,  
    63  
    effects of low emission on, 140  
    reactivation of, 64  
    supply sources of, 63

Filter, bleeder resistance in, 88  
    characteristics of, 85, 86, 88, 89,  
    143, 147, 149, 221, 272  
    crystal, 267  
    high-pass, 221  
    input choke type, 85, 149, 333

Filter, input condenser type, 85,  
    147, 221, 333  
    low-pass, 219, 272

Filter chokes, 85, 143, 147, 148,  
    221, 300  
    loose laminations in, 300

Filter condensers, 86  
    leakage test in, 333-334

Filter systems, function of systems  
    of, 333  
    voltage regulations in, 143

Fire extinguishing agent, 217

First aid, 112

Flash back, definition of, 219

Fluorescent screen use of, 197

Frequency, of auto-alarm receiver,  
    340  
    for calling airport, 174  
    checking of, 176  
    formula for, 35  
    measurement of, 2, 246, 247  
    problems relating to measure-  
        ment of, 179, 180, 291, 292,  
        304  
    resonant, 187  
    shift, 125  
    spark, 325, 326  
    standard, 245

Frequency deviation, permissible,  
    237, 245

Frequency doubler, purpose of,  
    137, 285, 342, 343

Frequency doubling problem, 269

Frequency doubling system, 49,  
    215  
    operation of, 67, 68, 262, 284

Frequency meter, 68, 69, 159, 225,  
    247, 277

Frequency modulation, 130, 198

Frequency monitor, 228

Frequency tolerance, 232, 242, 297

Fringe howl, method of reducing,  
    357

## RADIO OPERATING QUESTIONS AND ANSWERS

Full-wave rectifier, 87

overheating in, 88

Fuses, 105, 106

### G

Gain per stage, 191, 231, 245

Gaseous rectifier systems, 84, 334

Gaseous rectifier tubes, 89, 143, 334, 335

General call, types of, 296

Generation, of electrical potential, 18

of e.m.f., by sound waves, 357

Generators, care of, 103, 104, 145, 273

causes of sparking in, 145

characteristics of, 79, 146

core construction in, 76

filtering of, 86

frequency in, determining of, 79, 81

hunting effect in, 330

power rating of, 254

regulation of, 76, 145

self-excited, 79

third-brush type, 145

troubles in, 81, 103, 104, 105

voltage-output control in, 77, 274

Grid, blocked, 60

Grid bias, calculation of, 263, 293

failure of, 217

voltage of, 61, 66, 67, 70, 197, 262, 282, 312

Grid condenser, effect of shorted, 97

Grid control, purpose of, 262

Grid current changes in, 216, 315, 341

Grid detection, 64, 258, 259, 318

Grid drive (*see* Excitation)

Grid excitation, 159, 262, 300, 315

Grid leak, open, 98

purpose of, 138

Grid modulation, definition of, 126

systems of, 125, 312, 315

(*see also* Modulation)

Grounding, of metal parts, reasons for, 113, 305

### H

Half-wave rectifier, circuit diagram of, 88

Half-wave three-phase rectifier system, 83

Harmonic, definition of, 111

Harmonic output, 233, 240

Harmonic reduction, in audio amplifier, 282

in transmitters, 139, 161, 288

Harmonic suppression, 204

Hartley oscillator, comparison of, 138, 346

Head telephones (*see* Telephones)

Heising modulation, 122

theory of, 314, 315

use of dropping resistor in, 313

Hertz antenna, method of coupling to, 135

resonant frequency of, 108, 121

Heterodyne, versus autodyne reception, 266

Heterodyne frequency meter, 160, 225, 277

operating precautions of, 277

problems on, 168

"zero beat" adjustment, 247

High frequency, advantage of, 324

High-impedance microphones, types of, 315

High-level modulation (*see* Modulation)

High-pass filter, circuit diagram of, 221

## INDEX OF SUBJECTS

High-vacuum rectifier tubes, characteristics of, 84, 85  
Horsepower, definition of, 27  
electrical equivalent of, 249  
Hot-wire ammeter, 93  
Hunting, motor, 330  
Hydrometer, use of, 331  
Hysteresis losses, definition of, 302  
in transformer, 273

### I

Image frequency, 133, 134, 265, 267, 321, 357  
Impedance, matching of, 186  
of network, problems in, 178, 256, 303, 304  
unit of, 23

Indicating devices, 293  
protection of, against radio-frequency currents, 271  
Indicating instruments, 89-93  
Inductance, antenna-series, 342  
bank winding of, 23  
charred, repair of, 271  
choke coil, value of, 272, 273  
definition of, 26  
effects in, 34, 118, 120, 179, 182, 255, 265  
energy stored in, 118  
iron compound cylinder in, 344  
iron core of, 34, 265, 344  
parallel-connection, 255  
phase angle in, 117, 118  
problems in, 178-183  
unit of, 25

Inductive load, effect of, 307  
reactance of, 33, 34, 120  
Input power, calculation of, 238, 240, 317  
Insulators, antenna, 110, 345  
commercial, 20  
dirty, effect of, 345

Insulators, radio-frequency, 20  
Intercommunication, law on, 7  
Interference, broadcast, 318  
radio-frequency, for gaseous rectifier tubes, 89  
Intermediate frequency, calculation of, 321  
purpose of, in superheterodyne receivers, 321  
Interstage coupling systems, 46  
Inverse peak voltage, definition of, 220  
determination of, 222  
transformer requirements of, 334  
Iron core (*see* Core)  
Isolation in amplifiers, 191  
Isolation networks, 188, 191

### K

Keying methods, in radiotelegraph transmitters, 288-290, 346  
Kilo, definition of, 25

### L

Lag, current, 119  
Lateral recording system, 194, 195  
Laws, radio, 1-17, 166-176, 232, 247, 294-299, 347-356, 360  
Lead-acid cells, chemical composition of, 70, 71  
local action in, 74  
voltage of, 73  
License (*see* Operator license; Station license)  
Line equalizer, 192, 193  
Line level, value of, 192  
Line telephone, grounding of, 193  
Lines of force, direction of, 23  
Link coupling, advantage of, 289  
arrangement of, 136  
definition of, 69

## RADIO OPERATING QUESTIONS AND ANSWERS

Lissajous figures, meaning of, 225  
Load, on vacuum tube, 60  
Local action, 74, 99  
Loftin-White amplifier, 165  
Logs, 15, 16, 17, 169, 170, 177, 236, 297, 347, 350  
Loop antenna, bearing indications of, 337, 338, 339  
directional pattern of, 322, 337  
shielding of, 338  
(*See also* Direction finder)  
Losses, hysteresis, 273  
in transformer, 273  
Low-level modulation (*see* Modulation)  
Low-pass filter, circuit diagram of, 221  
definition of, 221  
use of network for, 272

### M

Magnetic coupling systems, 42, 43  
Magnetism, residual, 24  
Magnetomotive force, unit of, 27  
Marine transmitter, comparisons of, 328  
emission classification of, 500  
cycle type, 324  
method of reducing power in, 325  
self-rectified type of, 328  
use of crystal oscillator in, 329  
Master-oscillator power amplifier, advantage of, 137, 266-268, 329-330  
antenna loading, effect on, 268  
circuit adjustments of, 344  
Matching (*see* Impedance, matching of)  
MAYDAY (*see* Radiotelephone distress signal)  
Measurements, radio-frequency current, 292, 307, 308

Meg, definition of, 26  
Mercury-vapor tubes, advantages of, 143  
arc back in, 219  
characteristics of, 84, 85, 223  
conduction currents in, 143  
operating temperature in, 223  
voltage drop in, 218  
Meter, correction factor of, 253  
problems relating to, 30, 93, 94  
protection of, in radio-frequency circuits, 271  
radio-frequency types of, 307, 308  
use of permanent magnet in, 293  
Micro, definition of, 25  
Microphone, carbon, disadvantage of, 194, 315  
single-button, 54, 128, 315  
condenser-type, 127  
crystal-type, 128  
diaphragm of, 192  
dynamic-type, 192  
high-impedance types of, 315  
packing in carbon type of, 107  
ribbon-type, 126, 127  
sensitivity of, 128  
single-button carbon, 54, 128, 315  
velocity-type, 128  
Microphone amplifier, 123  
Milliammeter, plate-current connection, 271  
problems in, 30, 95, 96, 249  
Mixer, four-channel type of, 189  
switching clicks in, elimination of, 192, 193  
Modulated amplifier, bias adjustment in, 197  
characteristics of, 245, 261  
distortion in, 202  
grid-bias, efficiency of, 202

## INDEX OF SUBJECTS

Modulated amplifier, problems relating to, 310  
succeeding stage of, requirements of, 284  
variations in plate current of, 142

Modulation, antenna current change during, 130, 131, 269, 357  
class B, system of, 197  
current ratios of, 130, 131, 269  
definition of, 125, 126  
efficiency of, 312, 313  
envelope, 123, 311  
excessive, 129, 130, 216  
frequency, 130, 198  
frequency-shift, 201, 312  
grid, 125, 312  
Heising, 122, 313, 314  
high-level, 126, 240, 342  
high percentage of, 129, 201  
low-level, 127, 128, 198, 240, 313, 343  
monitor, 201  
peaks of, 201  
percentage of, 201, 203, 239, 245, 310  
change in, 130, 197  
plate-system, 312, 314  
power output during, 202, 230  
problems in, 199, 200, 209, 309, 310  
series, 198

Modulation transformer, shorted turn in, 129  
in side bands, 197, 214, 310

Modulators, class B, 129, 196  
advantages of, 198  
db problem relating to, 199, 203  
grid, 125  
Heising, 122, 314  
overexcitation of, 315  
overloading of, 200  
power-amplifier, 122-125

Modulators, power output of, 129  
requirements for, 317  
power requirements of, 310  
stage, 236  
transformer shorted turn in, 129

Motor, brush position in, 76  
care of, 145  
characteristics of, 78, 80, 81  
commutator on, purpose of, 78  
counter e.m.f. in, 78  
flat-compounded, 80  
hunting, 328  
open-field, effect upon, 77  
problems, relating to, 220, 221, 306, 307, 331  
purpose of, interpoles in, 77  
series type of, 81, 330  
shunt-wound, 53, 77  
sparking of, cause of, 77, 145  
speed regulator and starter of, 53, 145  
starter of, 144, 145, 330  
use of carbon brushes in, 81

Motor boating, cause of, 98

Motor generator, overheated, care of, 104  
comparison of, with vacuum-tube rectifier, 146

Motor starter, starting effects of, 144

Motor troubles, 274

Multivibrator, characteristics of, 158, 224  
operation of, 279

Mutual conductance, definition of, 57

Mutual inductance, problems in, 179, 181, 182

N

Negative carrier shift, 141  
Negative resistance, 156

## RADIO OPERATING QUESTIONS AND ANSWERS

Negative temperature coefficient, 153  
Neutral position, 76, 104  
Neutralization, grid, 25  
instruments used in, 163, 164, 270, 277  
meter precaution during, 287  
plate, 44, 46, 136  
plate voltage, removal of, in, 232  
in power amplifiers, 161, 269, 270, 286  
purpose of, 116, 246, 286  
of a push-pull amplifier, 136  
of a single amplifier, 136  
when not required, 231, 232  
Noisy operation, in regenerative receivers, 322, 324  
No-voltage release, function of, 112

### O

Obscene language, 6, 8  
Ohm's law, 27, 28  
in alternating-current circuits, 36, 117  
problems in, 28, 29, 30, 50, 114, 115  
Operating power, definition of, 238  
determination of, 238, 244  
measurement of, 238  
permissible, 295  
reducing of, in broadcast transmitters, 242  
tolerance in, 1  
Operation, resumption of, 3  
Operator, authority of, 166, 167, 176, 235, 296, 297  
Operator license, to citizen only, 7  
posting of, 167, 239, 298  
suspension of, 3, 16  
Oscillator, Armstrong, 38, 40  
Colpitts, 39, 138, 346  
crystal, 39, 41, 276, 301

Oscillator, dynatron, 279, 280, 288  
electron-coupled, 40, 280  
failure of, 98  
Hartley, 37, 138, 346  
heterodyne, adjustment ratio of, 247  
master, 137, 267, 268  
self-excited, 266, 312  
tuned-plate tuned-grid, 37, 38  
Overheating, of vacuum tubes, 142  
Overmodulation, effects of, 129, 130, 216

### P

Pads, line, purpose of, 188  
PAN (*see* Urgent signal)  
Parallel resistance, problems in, 249-252, 304  
Parallel-resonant circuit, determining the frequency of, 304  
determining the Q of, 303  
Parasitic oscillations, cause of, 139, 216  
definition of, 139, 345  
effect of, 345  
prevention of, 215  
Peak value, in antenna current, 130, 317  
in antenna power, 130  
of inverse voltage, 220, 234  
of a sine wave, 253, 311  
Penalties, 172  
Pentode tube, amplifier, construction of, 54, 55  
modulated amplifier for, 124  
as oscillator, 41  
purpose of suppressor grid of, 262  
Percentage deviation, definition of, 245  
Percentage modulation, definition of, 245  
high desirability of, 201

## INDEX OF SUBJECTS

Percentage modulation, measurement of, problems in, 203, 310  
requirements of, 239

Permanent magnets, use of, in telephones, 293

Permeability, definition of, 23, 302

Phase angle, 118

Phase difference, meaning of, 117, 254

Phase monitor, 226, 227

Physical height, calculation of, 211

Plate current, causes of excessive, 345  
changes in amplifier, 68, 142, 200-202, 216, 222, 228, 282, 342  
class B amplifier, variations, 200  
class B modulator, variations, 129  
detector, characteristics, 259, 318  
factors governing, 69

Plate detection, characteristics of, 134  
circuit diagram of, 47  
theory of, 259

Plate dissipation, 60  
in class B amplifiers, 200, 230

Plate efficiency, formula for, 185  
in radio-frequency amplifiers, 161, 186, 313  
problems in, 208, 216, 218, 310

Plate impedance, definition of, 57

Plate-input power, calculation of, 238  
definition of, 239, 240

Plate modulation, comparison of, 312  
definition of, 126  
Heising system of, 314, 315

Plate saturation, definition of, 61

Plate-tank circuit, adjustment of, 231, 344

Polarity, of charging, 100  
reversal of, in plate supply, 134

Polarization, definition of, 72

Police radio stations, 172

Portable transmitter, 241

Positive carrier shift, 201, 316

Positive temperature coefficient, 152

Potential, difference of, 18

Power, apparent, 254  
authorized, 247  
calculation of, 19, 20, 35, 238  
dissipation of, 19  
licensed, 247  
maximum allowed, 2  
maximum-rated carrier, 240  
measurements of, 24, 238  
modulated requirements of, 310, 317

plate input of, 238, 240, 317  
problems in, 29, 30, 31, 35, 249, 250-252, 310

reduction of, in broadcast transmitters, 242

unit of, 25, 118

Power antenna, calculations for, 130, 205-211, 238, 317

Power detection (see Plate detection)  
characteristics of, 259  
operating conditions in, 62  
theory of, 259

Power factor, definition of, 25, 27, 117, 255  
determination of, 117

Power input-output relations in amplifiers, 317

Power output, adjustment of, in telegraph transmitters, 324  
conditions governing maximum, 70  
during modulation, 197, 202, 317  
measuring of, 238

## RADIO OPERATING QUESTIONS AND ANSWERS

Power output, reducing of, in broadcast transmitters, 242  
of vacuum tube, ratio of, 70  
Power supply, calculation of, regulation in, 148, 222  
voltage regulation in, 148  
(*See also* Filters; Generators; Rectifiers)  
Power transformer (*see* Transformer)  
Preamplifier, problem relating to, 198, 199  
purpose of, 159, 190  
Priority of communications, 4, 11, 352  
Problems, relating to antenna, 110, 130, 205-211, 238, 317  
battery, 73, 331, 332  
class C amplifier for coupling transformer, 228, 229  
condenser, 32, 33, 148  
crystal oscillator, 224, 291  
decibel, 198-201  
emergency transmitter, 332  
frequency deviation, 168, 292  
frequency doubler, 223, 224, 268  
frequency meter, 168  
frequency tolerance, 167, 292  
grid bias, 263, 293, 340, 341  
image frequency, 133, 134, 262  
impedance, 117, 178-181, 186, 187, 303, 304  
meter, 93  
milliammeter, 30, 95, 96, 249  
modulation, 199, 200, 209, 309  
motor, 220-221, 306, 307, 331  
mutual inductance, 179, 181, 182  
Ohm's law, 28, 29, 30, 114, 115, 340  
parallel network, 178, 304  
parallel resonance, 304  
plate leakage, 218  
power, 27, 30, 31, 182, 249  
Problems, preamplifier-mixer, 198, 199  
reactance, 31, 33, 34, 118, 119, 120, 179  
resistance, 28-30, 114, 115, 247-251, 302  
resonance, 185, 302  
series-parallel resistance, 302  
series resonance, 119, 121  
superheterodyne receiver, 133, 134, 262, 319  
transconductance, 98  
transformer, 180, 181, 183, 271, 303  
transmission line, 205-209  
tube characteristics, 69, 215, 216  
vertical antenna, 209  
voltage divider, 115  
voltage gain, 229  
water-cooled tube leakage, 214, 215  
wave meter, 157, 158, 167  
Preselector stage, reasons for using, 263, 319  
Program circuit, equalizing of, 190, 193  
line level of, 190  
Protective condenser, arrangement of, 86  
reason for using, 325  
Push-pull amplifier, 136  
advantage of, 159, 258, 280  
class B audio-frequency requirements of, 258  
removal of tube in, 231

## Q

Q, code, 361-367  
of a coil, 23  
factors governing, 34, 303  
Quartz crystal, advantages of, 277  
cleaning of, 154, 277, 278

## INDEX OF SUBJECTS

Quartz crystal, effect of strain upon, 152, 279  
function of, in a transmitter, 153  
temperature coefficient of, 153, 278  
"X" cut, 154  
"Y" cut (*see* Crystal oscillator)  
Quartz oscillator (*see* Crystal oscillator)

### R

Radiation, problems dealing with, 205-211  
Radiation measurements, 205-207  
Radiation resistance, definition of, 120  
Radio beacons, 355  
Radio-frequency, comparison with audio-frequency amplification, 319  
indicating devices for, 293, 307, 308  
interference of, in tubes, 89  
minimizing of, 104  
neutralization of capacity of, in amplifiers, 116, 132, 133, 160, 319  
plate efficiency of, in amplifier, 162  
resistance, 205-207  
spark, discharge in, 154-155  
special, iron core construction of, 265, 266, 344  
Radio-frequency ammeters, 89, 90, 93, 96  
Radio-frequency amplifiers, excessive plate current, 283, 345  
Radio-frequency chokes, 116  
Radio laws (*see* Laws)  
Radio receiver, "A" battery substitution of, 346, 347  
auto-alarm, 335-337, 339, 340

Radio receiver, marine, 355, 356  
repair of, 134  
troubles in, 134, 135, 319, 320, 342  
tuning adjustments for, 131, 132, 263, 317-318  
Radio symbols, new ASA standard, 395-409  
Radiotelegraph, keying methods, 289-290  
key spark reduction in transmitters of, 270, 271  
purpose of power amplifier of, 341  
transmitter troubles in, 288, 289, 290  
Radiotelephone distress signal, 170  
Radio-wave emissions, types of, 311  
Ratio, of average-effective-peak, 302  
heterodyne oscillator to signal, 247  
impedance, in transformers, 185  
peak to effective, 253  
rectifier output to input, 269  
step up and step down, in transformers, 119, 256, 257, 273, 305  
tube to load, in class A amplifiers, 183  
Reactance, capacitive, calculation of, 21, 31, 118, 179, 300  
under conditions of resonance, 121  
inductive, calculation of, 33, 34, 120  
problems in, 179, 180  
Reactivation, vacuum-tube filament, 64, 257, 258  
Receiver (*see* Radio receiver)  
Recording, lateral system of, 194  
vertical system of, 193, 194

## RADIO OPERATING QUESTIONS AND ANSWERS

Rectifiers, bridge-type, 82, 218  
cold-cathode, 334  
characteristics of tubes in, 84, 85, 89, 143  
circuit arrangements of, 87, 88  
comparison of half-wave and full-wave, 82, 146  
copper oxide, 94, 96  
filter use with, 85, 86, 89  
gaseous, 84, 334  
high-vacuum type of, 84, 334-335  
inverse peak voltage rating of, 218, 334  
mercury-vapor type of, 84, 89, 143, 334-335  
overheating in, 88, 149  
ripple frequency in, 88, 269  
synchronous, 144  
transformer requirements in, 334  
troubles in, 149, 219  
voltage regulation in, 148  
vacuum-tube, advantage of, 146  
Reduced power, reasons for operation at, 232, 242, 324  
Regeneration, adjustment for, 131  
detector system of, 48, 132  
reasons for, in C-W reception, 131  
Regenerative receiver, 48  
adjustment of, 131, 132, 317, 318, 363  
disadvantage of, 263-264  
effect of, with type B emission, 318  
low sensitivity in, 98  
noisy operation in, 322-323  
operating failure of, 97, 98, 266, 319  
oscillating test in, 318-319  
Regulation (see Voltage regulation)  
Regulations, 1-18, 166-176, 232-247, 294-301, 346-357, 360

Relay, break-in, 322, 324  
broadcast station, 235  
contact material for, 111  
interlock, purpose of, 113  
polarized, 106, 107  
reverse-current, 105  
time-delay, 223  
self-wiping contacts, in connection with, 292-293  
Reluctance, definition of, 34  
effect of, in choke coil, 147  
Remote control, 299  
Repulsion-type meter, 91, 92  
Residual magnetism, meaning of, 24, 249  
Resistance, antenna measurement of, 205-207  
change of, with temperature, 110  
for equalizing, 149  
measurement of, 19, 20, 24  
power dissipation in, 249, 250  
problems in, 28, 29, 30, 114, 115, 249-253, 304  
unit of, 24  
Resistance coupling, 42, 260  
Resistance multiplier, in voltmeter, 93  
Resistance network, 50, 52  
Resonant-frequency, methods of changing, 108, 120, 121, 256, 303  
physical relation to, in antennas, 108, 109, 110  
Resuscitation from shock, 112  
Ribbon-type microphone, construction of, 126, 127, 128

S

Safety signal, 8, 9, 170, 295, 352, 353  
Saturation, core, prevention of, 190

## INDEX OF SUBJECTS

Screen grid, neutralizing requirements of, in tube, 162  
purpose of, 61, 260  
(*See also* Tetrode)

Secondary emission, in a dynatron oscillator, 288

Secrecy of communications, 5, 6

SECURITY (*see* Safety signal)

Selectivity, of three-circuit tuner, controlling of, 264

Self-excited oscillator, antenna-loading effect on, 268, 292, 343  
disadvantages of, 267, 268, 292, 312, 313, 342  
frequency shift in, 125  
modulation requirements of, 312-313

Self-wiping contacts, relay, 292-293

Sensitivity, low, in regenerative receiver, 98

Series, modulation, 198  
resistances connected in, 28, 29, 114, 250, 304

Series-parallel, resistances connected in, 114, 304

Series-resonant circuit, problems in, 119, 121  
reactance in, 120

Shielding, effects of, 256  
material used for, 22  
purpose of, 132, 188, 286

Shock, method of treating for, 112

Short circuit, in by-pass condenser, 99, 341  
effect of, in power transformers, 333

Side bands, in output wave, 197, 214, 311

Silent period, 348

Single-phase rectifiers, 86, 87  
circuit of, rectifier, 87, 88

Single-phase transformer, problems in, 183

Skin effect, definition of, 120

Soldering, core material used in, 111

Sound waves, generation of e.m.f. by, 357

Spark discharge, oscillatory, 154-156

Spark transmitter, frequency of, 325-326  
fundamental, 151  
optimum coupling in, 324-325  
power reduction of, 325

Speech amplifiers, impedance matching in, 186  
overexcitation of, 159  
uses of, 316

Split tuning, causes of, 344  
definition of, 324

Square-law detector, 65

Stabilized feedback, definition of, 192

Stage amplification, definition of, 245

Station license, 232

Storage batteries, 72, 73, 74, 276  
care of, 100, 101, 102, 103, 276, 331, 332  
charging of, 100, 102, 331, 332  
Edison-type, 331  
low specific-gravity effects in, 331  
problems dealing with, 73, 332  
temperature effects in, 275-276  
water selection for, 332

Sulphation, cause of, 102  
definition of, 74

Superheterodyne receiver, "image" frequency of, 133, 134, 265, 321, 357-358  
mixer-tube function, 265  
preselector stage of, 265, 321  
problems relating to, 133, 134, 264, 321

## RADIO OPERATING QUESTIONS AND ANSWERS

Superheterodyne receiver, purpose of, intermediate frequency, 321  
Superregenerative receiver, description of, 265  
Suppressor grid, purpose of, 61  
Surge impedance (*see* Transmission line)  
Swinging choke, 86, 148, 272  
Symbols, standard radio and electrical, 395-409

### T

Tank circuit, flywheel effect, 255  
Telephones, high-reactance, 107, 263  
low-impedance, 108  
use of permanent magnets in, 293  
Temperature coefficient, low, 152, 278, 279  
coefficient, negative, 152, 278  
coefficient, positive, 152, 279  
coefficient, problem in, 224, 291  
Temperature control, in oscillators, 153, 224, 225, 278  
Temperatures, low, effect of, in storage cells, 275  
Tests, 235, 294  
Tetrode tube, advantage of, 61, 62  
construction of, 55, 56, 57  
purpose of screen grid in, 61  
Thermocouple meter, construction of, 89, 90  
increasing range of, 94  
precautions when using, 287  
Thermostats, comparison of, 224  
Three-phase-wattmeter connections, 180  
Thyatron, definition of, 54  
Time-delay relay, in mercury-vapor circuits, 223  
Time zone, 347  
Tolerance, of antenna current, 241  
of power, 235

Tolerance frequency, 241, 242  
Transconductance, definition of, 57  
problem in, 98  
Transformer, core construction of, 271  
Transformer coupling, comparison of, with resistance coupling, 260  
frequency, effect of improper, 305-306  
grounding of, 305  
impedance ratio of, 185, 228, 305  
power of, problems in, 180, 272  
ratio of, 119, 228, 256, 257, 273, 305  
short circuit, in secondary of, 333  
single-phase, with rectifier, 83  
in tetrode audio-frequency amplifiers, 67  
turns ratio of, calculation in, 305  
use of, with direct current, 83, 119, 257  
used with rectifier, 82  
voltage output of, with rectifier, 82, 334  
Transmission line, circuit of, 205  
problems relating to, 207-211  
quarter-wave, 209, 210  
Transmitter, comparison with spark transmitter, 328  
emergency, problem relating to, 332  
lifeboat, 343  
neutralization of, 160, 269-270, 286-287  
self-rectified type of, 328  
troubles of and remedies for, 109, 141, 142, 201, 202, 272, 288, 289, 342  
tuning precaution for, 270, 344  
Triode tube, construction of, 56  
Troubles, auto-alarm, 335-337, 339  
receiver, 97, 98, 264, 320-321, 342

## INDEX OF SUBJECTS

Troubles, transmitter, 109, 141, 142, 230, 270, 343, 345

Tube efficiency, in class A amplifier, 214

plate, problem in, 208, 215, 216, 217, 218

Tuning, precautions in, 270

of regenerative receiver, 131, 132, 263, 317-318

Tuned audio-frequency amplifier, advantages of, 284-285

Tuned-plate tuned-grid oscillator, 37, 38

method of obtaining feedback in, 138, 139

Tuned radio-frequency amplifier, 132, 133

preselector stage of, 265

Turns ratio, calculation of, 119, 228, 256, 257, 273, 305  
(*See also Ratio*)

Twenty-four-hour time system, 347

U

Unity coupling, definition of, 163

in radio-frequency transformers, 183

Unnecessary signals, 8

Urgent signals, 8, 9, 10, 170, 295, 296, 349, 355

V

V U (*see Volume unit*)

Vacuum tube, blue haze in, 149, 258

cathode-heater type, 257

characteristics of, 60-62

construction of, 54

control grid of, 262

defects of, 140, 142, 345

detector action on, 64

load on, 60

Vacuum tube, mercury-vapor type, 84, 85, 143, 223

pentode of, 54, 55, 260

reactivation filament of, 257, 258

soft, 54, 56

tetrode, 61, 262

water-cooled, 211

milliammeter connection in, 213, 214, 216

Variometers, use of, in transmitters, 346

Velocity-type microphone, 128

Verification card, 168, 169

Vertical recording system, 193, 194

Violations, 4

Voltage divider network, 115, 251

problem relating to, 115

Voltage drop, calculation of, 19

in mercury-vapor tubes, 218

Voltage gain, factors affecting, 60, 189

problem in, 231

V U, 191-192

Voltage regulation, definition of, 76, 307

of dynamotor, 220

in power supplies, 148

in rectifiers, 143, 221, 222

Voltmeter, correction factor of, 253

multiplier resistance, purpose of in, 96

problems in, 93, 94

uses of a, 24

Volume unit, definition of, 191-192

W

Water-cooled tube, diagram of, 213

type of water recommended for, 217

Wattmeter, connections, 180

construction of, 89, 90

problem in, 292

wavelength, formula for, 36

*RADIO OPERATING QUESTIONS AND ANSWERS*

Wavemeter, problems relating to,

Y

158, 159, 277

Wave-trap circuit, 52

Y-cut crystal, temperature coefficient of, 152, 279

X

Z

X-cut crystal, temperature coefficient of, 153, 154, 278

Zero beat, definition of, 276-277



